Radiological Health Data

VOLUME IV, NUMBER 5

May 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editiorial Advisors with representatives from the following Federal agencies:

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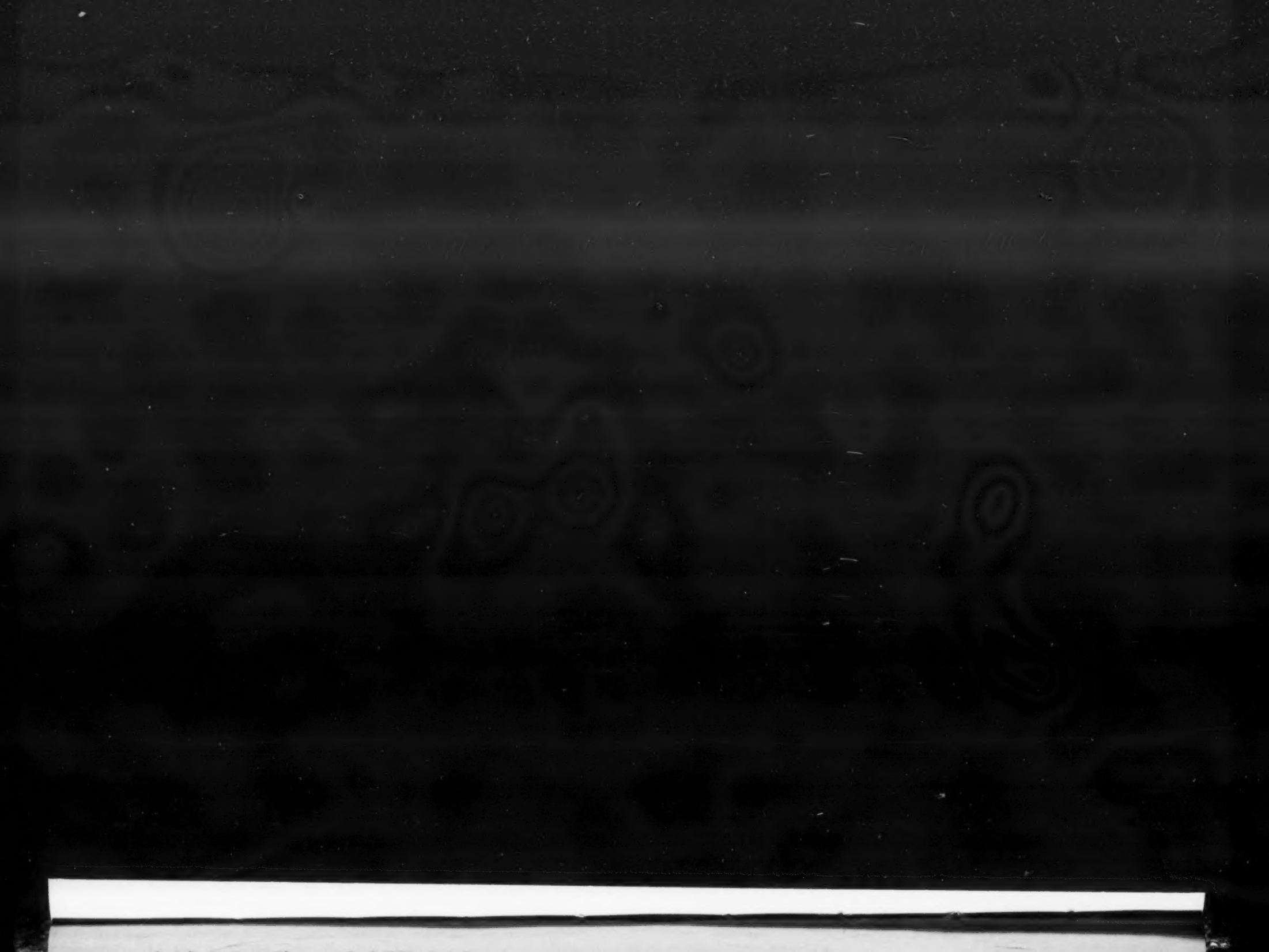

RADIOLOGICAL HEALTH DATA

VOLUME IV, NUMBER 5
MAY 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuation in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through such surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide to when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

January 1963 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Because of differences in equipment and techniques, the results from one network are not directly comparable with those of another. However, some intercalibration factors have been determined in a study conducted by Lockhart and Patterson of the U. S. Naval Research Laboratory (*1*, *2*). An application of the results of this study is presented in figure 3, in which the January gross beta in air data from Canada and the U. S. were combined in one contour map. To adjust to a common baseline, the U. S. data were multiplied by a factor of 1.54, the U. S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCES

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466-70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK

January 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State health department personnel.

Air

Daily 24-hour air samples are collected by a high-volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a $Sr^{90-90}Y$ known activity source. This determination is usually made about 5 hours after collection to eliminate interference from naturally occurring radon daughters. The Network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day

interval, are used to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The average fission-product beta concentrations in surface air during January 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare these data with the gross beta reported by Canada, an adjustment is required. The relationship given by Lockhart and Patterson[1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

Because of the higher filter efficiency and lower self-absorption in the Canadian system compared with RSN,[1] it was considered more appropriate to adjust the RSN values upward to correspond with Canada rather than to adjust the Canadian data downward.

The Canadian air data and the adjusted RSN data rendered the concentration contour map in figure 3, which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels with collection areas of 0.4 m². A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall) the volume of precipitation is reported, but no analysis is made. January 1963 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu$c/liter) and millimicrocuries per square meter (mμc/m²), are presented in table 2.

* In this expression, A is the activity and T is the time after fission product formation.

[1] See references (*1*) and (*2*) on page 225

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, JANUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station location		Number of samples	Maximum	Minimum	Average[a]
Alaska:	Adak	29	9.5	<0.10	3.3
	Anchorage	30	14	<0.10	3.9
	Attu	31	31	<0.10	4.8
	Fairbanks	23	11	0.53	4.2
	Juneau	24	16	<0.10	3.8
	Kodiak	17	26	<0.10	6.4
	Nome	26	6.7	<0.10	2.8
	Point Barrow Island	23	7.9	1.3	4.5
	St. Paul Island	14	9.1	0.45	4.7
Ariz:	Phoenix	29	25	5.3	13
Ark:	Little Rock	28	15	1.7	9.3
Calif:	Berkeley	30	22	0.53	10
	Los Angeles	21	23	7.5	15
Colo:	Denver	29	21	6.3	10
Conn:	Hartford	30	11	0.56	5.9
Del:	Dover	22	19	3.5	8.8
D.C:	Washington	31	14	1.2	5.7
Fla:	Jacksonville	29	20	4.1	11
	Miami	30	20	1.6	8.5
Ga:	Atlanta	31	10	0.19	5.5
Guam:	Agana	[b]—	—	—	—
Hawaii:	Honolulu	30	11	1.7	5.1
Idaho:	Boise	30	20	3.1	9.0
Ill:	Springfield	30	9.4	1.4	5.6
Ind:	Indianapolis	29	11	0.57	6.0
Iowa:	Iowa City	28	8.4	0.99	4.5
Kans:	Topeka	28	11	1.7	6.5
Ky:	Frankfort	29	24	2.7	11
La:	New Orleans	29	16	0.59	7.6
Maine:	Augusta	31	12	1.8	6.3
	Presque Isle	19	8.2	1.3	4.4
Md:	Baltimore	22	12	0.45	5.4
	Rockville	14	12	3.0	7.3
Mass:	Lawrence	29	12	1.5	6.4
	Winchester	28	20	4.3	10
Mich:	Lansing	31	12	2.5	7.9
Minn:	Minneapolis	29	9.1	1.6	6.2
Miss:	Jackson	29	11	1.2	9.2
	Pascagoula	21	18	2.0	9.0
Mo:	Jefferson City	30	12	1.2	6.2
Mont:	Helena	30	15	3.6	8.8
Nebr:	Lincoln	19	13	1.3	5.9
Nev:	Las Vegas	28	35	5.6	17
N.H:	Concord	20	17	4.7	9.6
N.J:	Trenton	31	13	0.31	.3
N. Mex:	Santa Fe	27	16	5.3	8.6
N.Y:	Albany	28	12	0.72	5.5
	Buffalo	29	11	1.3	7.4
	New York	15	7.7	2.1	5.3
N.C:	Gastonia	30	27	1.3	9.9
N. Dak:	Bismarck	30	13	3.3	7.9
Ohio:	Cincinnati	21	11	1.3	5.7
	Columbus	29	12	1.1	7.0
	Painesville	30	16	1.4	7.7
Okla:	Oklahoma City	30	12	2.7	7.0
	Ponca City	30	6.2	1.4	3.8
Ore:	Portland	27	29	1.2	11
Pa:	Harrisburg	21	10	0.32	5.5
P.R:	San Juan	22	5.6	1.1	3.1
R.I:	Providence	30	13	0.91	6.7
S.C:	Columbia	27	13	0.82	6.6
S. Dak:	Pierre	29	9.7	2.8	6.0
Tenn:	Nashville	28	16	2.1	6.7
Tex:	Austin	31	16	1.9	8.7
	El Paso	31	17	2.8	8.0
Utah:	Salt Lake City	31	18	3.8	10
Vt:	Barre	31	15	2.0	8.2
Va:	Richmond	30	11	2.1	5.5
Wash:	Seattle	30	16	0.53	7.1
W. Va:	Charleston	22	13	2.1	7.2
Wisc:	Madison	31	13	2.2	7.0
Wyo:	Cheyenne	27	20	2.9	7.8
Network average					7.2

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

[b] Dash indicates no sample received.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, JANUARY 1963

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^3$)
Alaska:	Adak	*	*
	Anchorage	1,700	32
	Attu	*	*
	Fairbanks	2,300	100
	Juneau	1,500	98
	Kodiak	*	*
	Nome	*	*
	Point Barrow Island	*	*
	St. Paul Island	*	*
Ariz:	Phoenix	*	*
Ark:	Little Rock	3,500	64
Calif:	Berkeley	840	79
	Los Angeles	2,200	3.8
Colo:	Denver	*	*
Conn:	Hartford	2,400	120
Del:	Dover	*	*
D.C:	Washington	2,000	96
Fla:	Jacksonville	1,400	94
	Miami	3,200	27
Ga:	Atlanta	*	*
Guam:	Agana	*	*
Hawaii:	Honolulu	*	*
Idaho:	Boise	2,700	9.8
Ill:	Springfield	3,300	7.5
Ind:	Indianapolis	2,000	45
Iowa:	Iowa City	*	22
Kans:	Topeka	*	*
Ky:	Frankfort	4,300	89
La:	New Orleans	1,300	180
Maine:	Augusta	1,300	120
	Presque Isle	*	*
Md:	Baltimore	3,100	2.4
	Rockville	*	*
Mass:	Lawrence	2,400	120
	Winchester	1,900	140
Mich:	Lansing	*	*
Minn:	Minneapolis	2,600	12
Miss:	Jackson	1,900	73
	Pascagoula	*	*
Mo:	Jefferson City	2,000	14
Mont:	Helena	2,600	22
Nebr:	Lincoln	8,000	23
Nev:	Las Vegas	*	*
N.H:	Concord	*	*
N.J:	Trenton	3,400	13
N. Mex:	Santa Fe	5,600	57
N.Y:	Albany	520	9.5
	Buffalo	510	10
	New York	*	*
N.C:	Gastonia	670	56
N. Dak:	Bismarck	3,600	15
Ohio:	Cincinnati	*	*
	Columbus	2,200	77
	Painesville	9,700	220
Okla:	Oklahoma City	6,200	40
	Ponca City	1,100	25
Ore:	Portland	3,600	76
Pa:	Harrisburg	*	*
P.R:	San Juan	440	120
R.I:	Providence	1,700	130
S.C:	Columbia	970	150
S. Dak:	Pierre	*	*
Tenn:	Nashville	7,400	12
Tex:	Austin	3,400	36
	El Paso	11,000	24
Utah:	Salt Lake City	5,900	100
Vt:	Barre	2,200	170
Va:	Richmond	1,700	66
Wash:	Seattle	2,700	63
W. Va:	Charleston	2,600	43
Wisc:	Madison	760	17
Wyo:	Cheyenne	1,700	8.6

* Indicates no evaporated sample received.

REFERENCE

(1) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM

January 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation at 24 stations located at airports (see figure 2). The sampling equipment at these stations is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's reports (*1-5*).

FIGURE 2.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for January 1963 are given in table 3, and presented in conjunction with U. S. adjusted air data in the concentration contour map (figure 3).

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. January 1963 precipitation data for Canada, including some radiochemical analyses, are shown in table 4.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, JANUARY 1963

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	29	42.0	2.1	17.7
Coral Harbour	30	13.0	0.0	4.4
Edmonton	23	31.0	3.1	11.3
Ft. Churchill	30	8.2	1.0	4.3
Ft. William	30	18.4	2.2	9.4
Fredericton	31	19.8	0.8	9.6
Goose Bay	30	10.7	1.1	5.6
Inuvik	31	29.0	3.6	11.8
Montreal	31	25.0	4.9	11.5
Moosonee	27	29.5	2.3	9.0
Ottawa	31	27.0	4.2	12.4
Regina	30	31.0	3.9	13.6
Resolute	29	11.0	0.8	5.7
Saskatoon	31	36.0	4.2	13.9
Sault Ste. Marie	31	23.2	2.8	11.5
Shearwater	31	33.0	0.6	11.1
Torbay	31	26.2	1.0	10.1
Toronto	30	41.0	4.8	14.6
Vancouver	31	38.0	0.9	12.1
Whitehorse	30	26.0	2.6	9.6
Windsor	31	22.0	5.6	14.1
Winnipeg	30	20.0	2.7	10.0
Yellowknife	31	16.2	4.5	9.6
Average				10.6

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Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
November 1962	*March 1963*
December 1962	*April 1963*

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, JANUARY 1963

Station	Total beta activity		Deposition of specific radionuclides for selected samples[1, 2] (mμc/m²)				
	μμc/liter	mμc/m³	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	3,308	84.0	5.00	0.25	13.4	0.35	3.06
Coral Harbour	8,462	64.5					
Edmonton	2,523	93.5					
Fredericton	991	110.6					
Fort Churchill	1,287	31.1					
Fort William	4,478	54.6					
Goose Bay	613	67.3					
Inuvik	3,139	114.0					
Montreal	1,594	66.4	6.35	0.25	9.86	0.47	2.50
Moosonee	1,111	33.0					
Ottawa	1,674	63.7					
Quebec	757	49.1					
Regina	6,545	29.9					
Resolute	4,618	140.7					
Saskatoon	2,877	39.4					
Sault Ste. Marie	1,234	65.5					
Shearwater	1,415	204.5	11.9	0.51	44.5	1.12	7.20
Torbay	1,652	252.5					
Toronto[3]	—	—					
Vancouver	2,181	87.5	10.4	0.47	11.2	0.73	3.37
Whitehorse	3,871	77.7					
Windsor	2,589	73.6					
Winnipeg	6,366	42.0	4.48	0.19	5.70	0.34	2.86
Yellowknife	3,118	63.3					
Average	2,887	83.0					

[1] All values corrected for decay back to end of collection month.
[2] Values for strontium–90, cesium–137, and zirconium–95 do not include the activities of their daughter isotopes, yttrium–90, barium–137, and niobium–95.
[3] No sample.

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(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, CNHW* (*RPD-21*), (August 1962).

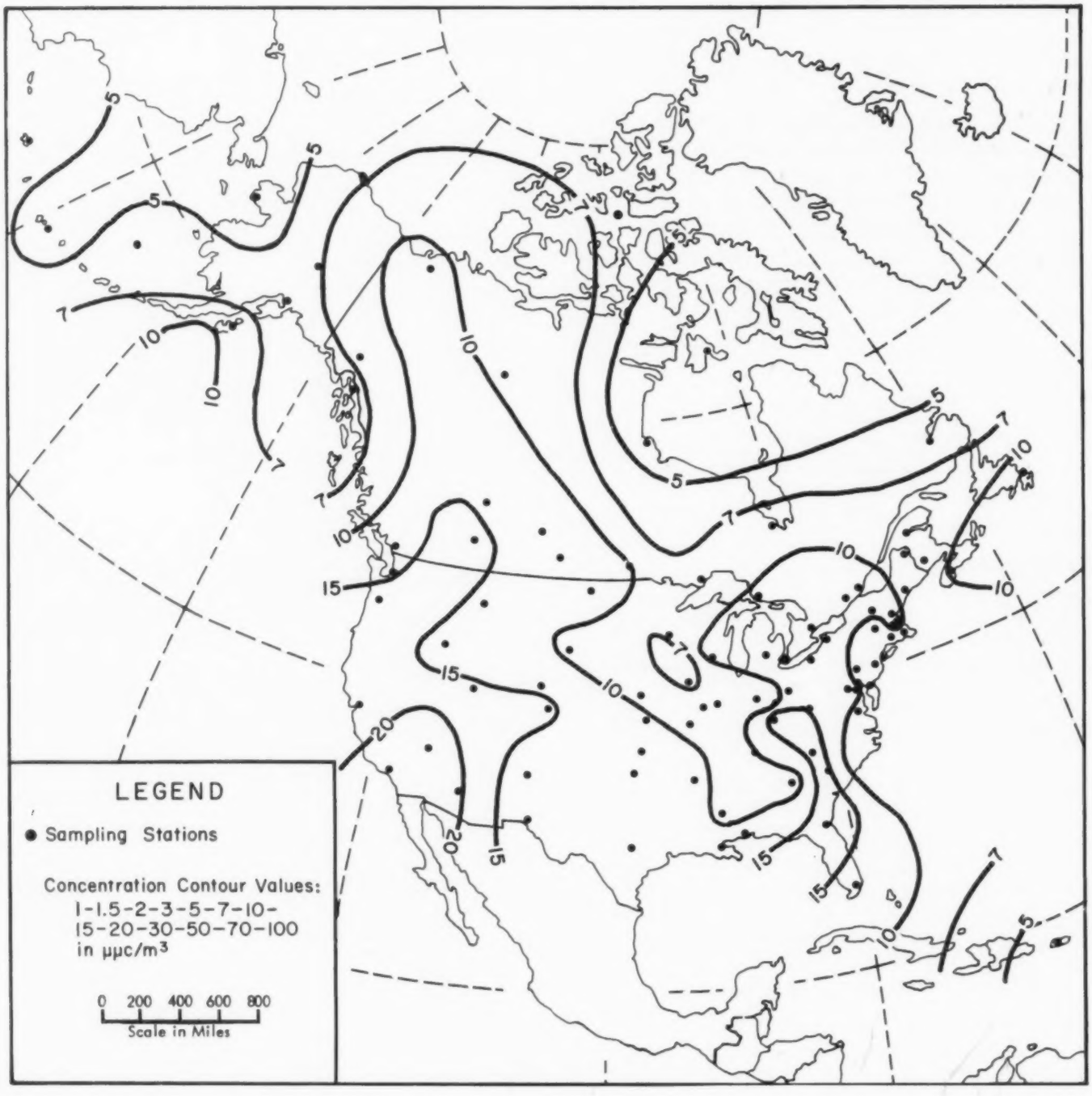

FIGURE 3.—AIRBORNE GROSS BETA CONCENTRATION CONTOURS FOR CANADA AND THE U. S. JANUARY 1963

MEXICAN RADIOACTIVE FALLOUT PROGRAM

January 1963

Radiological Protection Program National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, eleven of which were in operation by the end of January 1963.

Eight of the twelve stations are located at airports and operated by airline personnel. The remaining four stations are located at Mexico City, Mérida, Veracruz, and San Luis Potosí. Staff members of the RPP operate the station at Mexico City, while the other three stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, and the Instituto de Zonas Desérticas of the University of San Luis Potosí, respectively.

In December 1962, the station located in Tijuana was moved to Ensenada, a city on the Pacific Coast 60 miles from Tijuana, where it is operated by the staff members of the Escuela Superior de Ciencias Marinas of the University of Baja, California.

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6" x 8" high-efficiency glass fiber filter using high-volume samplers. After each 24-hour period, the filter is removed and airmailed to the Laboratorio de Desechos Radiactivos (CNEN) in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission-product beta concentrations in surface air during January 1963 are presented in table 5.

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JANUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	5	5.5	0.6	3.96
Ciudad Juárez	6	29.9	9.2	22.55
Ensenada	13	39.9	10.7	16.73
Guadalajara	12	14.2	1.8	5.78
La Paz	14	19.7	4.0	9.37
Mérida	15	42.6	3.3	12.97
México	12	4.2	2.1	3.35
San Luis Potosí	12	9.3	1.4	5.50
Torreón	12	38.5	3.5	13.96
Veracruz	21	17.8	0.4	4.15
Tuxtla Gutierrez	19	15.4	0.15	4 58

SECTION II.—MILK

Milk Surveillance

Produced and consumed on a regular basis, milk is convenient to handle, is easily analyzed, and representative samples of milk consumed in any given area are easily obtained. Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment because fresh milk is consumed by a large segment of the U. S. population and contains most of the radionuclides identified as being biologically important.

PASTEURIZED MILK NETWORK
January 1963 and Annual Summary for 1962

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

JANUARY 1963

Raw milk studies were started by the Public Health Service in 1957 to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960 the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling and analytical data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During January 1963, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies. These samples, preserved with formaldehyde, are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Data from gamma analyses (iodine-131) are available to State public health officials and the Federal Radiation Council approximately 3 to 6 days after sample collection for possible public health action. Publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States; additional points to be established when the requirements are indicated by widely varying conditions of the milk supply or when needed in order to cover large population groups. Each sample is a composite of subsamples which are specified to be collected from each plant

in proportion to the relative volumes of milk sold. Each of the 62 stations reflects from 80 to 100 percent of the milk consumed in that city, with the network average being about 90 percent. Prior to September 15, 1961, the composite of a sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling frequency has been increased. During January 1963, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Minimum Reportable Concentrations

Iodine-131, cesium-137, and barium-140 are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 are determined by radiochemical procedures. Minimum reportable concentrations used, in units of $\mu\mu c$/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Milk Collection and Distribution Times

A number of factors influence the concentration of radionuclides in milk. One factor (which may not be the most important) is the decay of radionuclides, particularly the short-lived ones, due to transfer times involved in collection and distribution of milk.

Table 1 gives a rough estimate of the times involved in the movement of pasteurized whole milk through the various stages from production to consumption. The headings in table 1 may be explained by the following statements. "Milking to processing plant" is the time required for storage on the farm and pickup and delivery to the processing plant. "In Processing plant" includes the time for storing raw milk in the processing plant, pasteurizing, transferring the milk through the plant, and storing the processed milk in cartons. "Processing plant to consumer purchase" is the time for delivering the milk from the processing plant to retail outlets and storing in the retail store. "Consumer purchase to consumption" is the time the milk is kept by the consumer before consumption in the usual liquid form. Thus, "Total time, milking to consumption" is the estimated total time between the time of milking and the consumption of the pasteurized fluid milk.

The ranges shown in table 1 do not imply that some milk processing plants distribute milk that is fresher than others. The chain of milk production involves assembling small quantities of milk from many individual farms into larger volumes for processing. The assembled milk is a composite of the times shown in the range. Consequently, part of the milk in a carton will be fresher than another part. Modern standards of biological cleanliness are high and the actual age difference between the fractions of milk in the carton has little bacteriological significance.

However, the total elapsed time is important in assessing the radiation dose from a short-lived nuclide such as iodine-131 ($T_{\frac{1}{2}}$ = 8.05 days). Figure 1 presents graphically the effect of the radioactive decay of iodine-131. Although analyses of milk samples are performed 1 to 4 days after collection, the data presented in table 2 have been

[1] See page 139 of March *Radiological Health Data*.

TABLE 1.—NORMAL TIMES REQUIRED FOR THE MOVEMENT OF PASTEURIZED WHOLE MILK FROM THE FARM TO THE CONSUMER [1]

	Time in hours required for:				
	Milking to processing plant	In processing plant	Processing plant to consumer purchase	Consumer purchase to consumption	Total time, milking to consumption
Range	2–44	1–8	0–48	0–72	3–148
Average	23	4.5	24	36	75.5

[1] Data supplied by the Milk Industry Foundation.

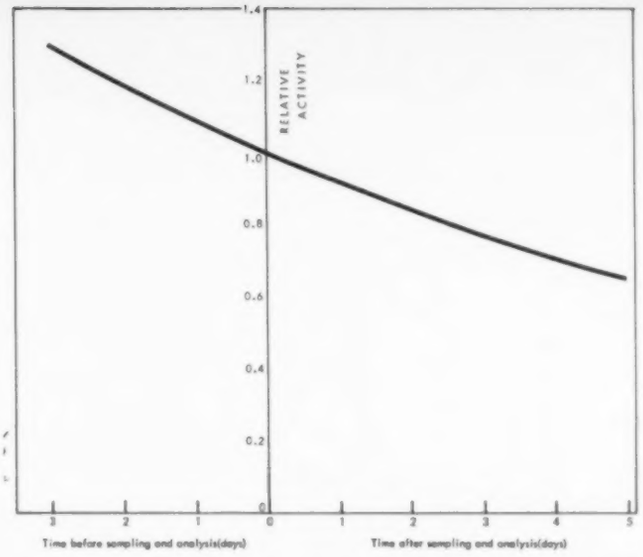

FIGURE 1.—RELATIVE DECAY OF IODINE-131 (HALF-LIFE = 8.05 DAYS)

extrapolated to the time of collection. Samples are usually collected from cartons at or near the end of the processing period.

Data Presentation

Table 2 presents summaries of all available analyses for January 1963 (December 30, 1962-January 26, 1963). When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average. Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.4 to 1.7 grams/liter. In January, for example, 12, 18, 24, and 4 stations reported respective monthly average potassium concentrations to be 1.4, 1.5, 1.6, and 1.7 grams/liter.

Figures 2-4 are concentration contour maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station.

Discussion of Data

In January 1963 the amount of iodine-131 appearing in milk (figure 2) over the entire country changed abruptly from that for the previous month. During December 1962 most of the country had monthly average concentrations from 20 to

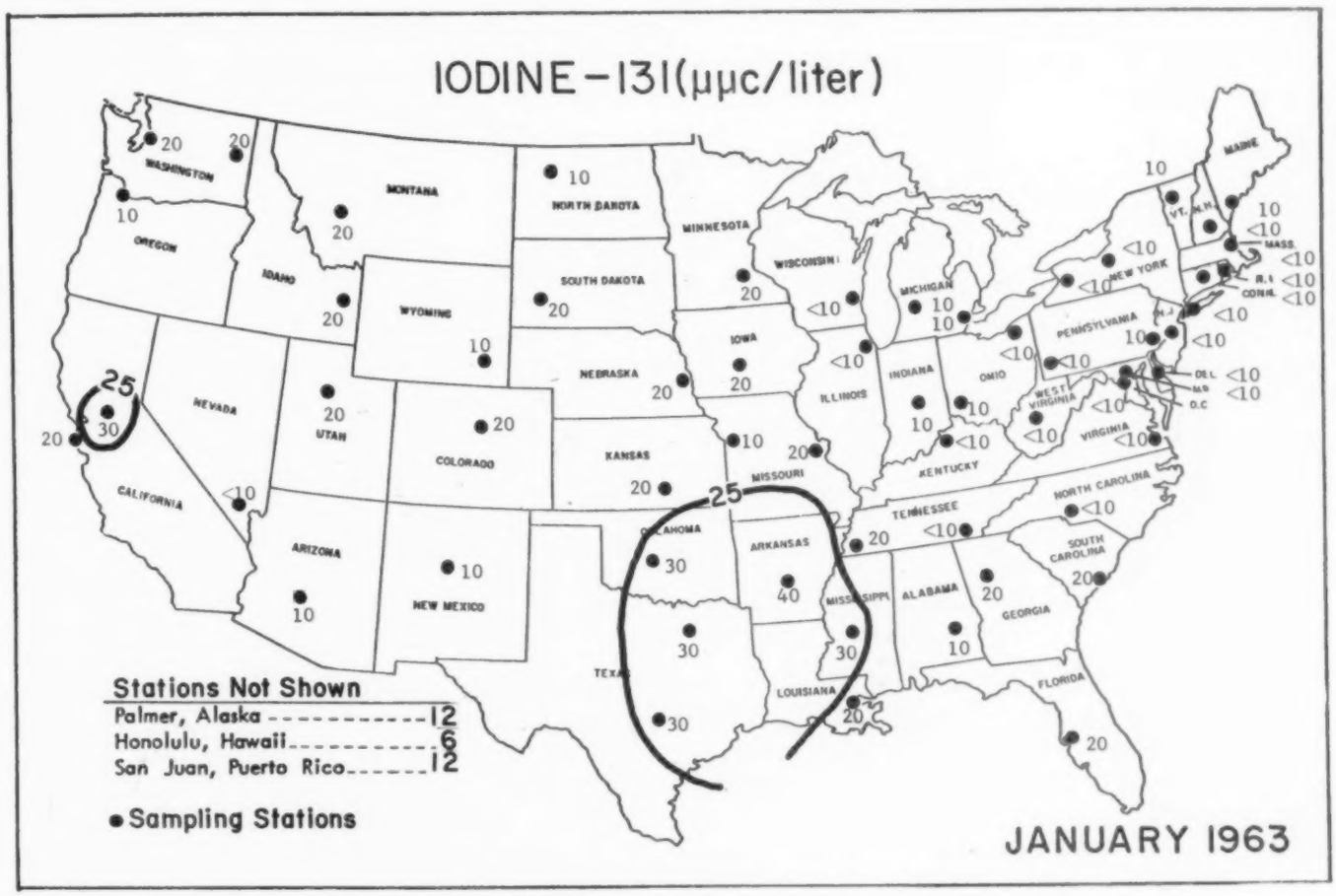

FIGURE 2.—IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2. RADIOACTIVITY IN PASTEURIZED MILK, JANUARY 1963

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.26	1.28	40	80	15	15	40	10	35	45	20	10
Alaska:	Palmer	1.33	1.24	80	25	13	12	110	20	60	85	30	10
Ariz:	Phoenix	1.32	1.26	25	25	5	4	20	10	20	20	<10	<10
Ark:	Little Rock	1.26	1.23	120	125	29	29	110	40	70	70	30	20
Calif:	Sacramento	1.32	1.29	20	15	4	3	20	30	20	25	10	<10
	San Francisco	1.34	1.34	20	60	4	5	20	20	20	25	<10	20
Colo:	Denver	1.34	1.34	20	10	11	13	20	20	55	70	<10	<10
Conn:	Hartford	1.13	1.12	40	5	11	12	40	<10	65	70	10	<10
Del:	Wilmington	1.11	1.16	50	10	15	16	80	<10	70	75	20	<10
D. C:	Washington	1.20	1.21	40	10	18	13	60	<10	55	55	20	<10
Fla:	Tampa	1.25	1.24	30	30	10	12	50	20	125	100	10	<10
Ga:	Atlanta	1.24	1.25	55	85	17	18	60	20	55	70	20	10
Hawaii:	Honolulu	1.26	1.19	20	40	6	6	20	20	40	45	<10	<10
Idaho:	Idaho Falls	1.31	1.25	25	10	13	13	40	20	75	75	10	10
Ill:	Chicago	1.12	1.12	45	<5	12	14	70	<10	65	75	10	<10
Ind:	Indianapolis	1.17	1.16	50	10	13	15	80	10	55	65	10	<10
Iowa:	Des Moines	1.36	1.28	75	20	14	14	110	20	50	60	20	<10
Kans:	Wichita	1.34	1.32	55	30	13	12	70	20	40	50	20	<10
Ky:	Louisville	1.23	1.23	95	30	23	21	80	<10	45	55	40	<10
La:	New Orleans	1.28	1.27	70	160	24	30	70	20	60	75	20	20
Maine:	Portland	1.15	1.09	50	<5	17	20	50	10	110	105	20	<10
Md:	Baltimore	1.22	1.22	40	<5	17	15	60	<10	60	60	20	<10
Mass:	Boston	1.13	1.16	60	5	19	18	50	<10	100	100	20	<10
Mich:	Detroit	1.13	1.16	50	5	15	16	70	10	75	75	20	<10
	Grand Rapids	1.18	1.18	35	10	12	15	50	10	65	75	10	<10
Minn:	Minneapolis	1.32	1.24	70	15	23	20	70	20	95	105	30	<10
Miss:	Jackson	1.30	1.34	90	170	19	25	70	30	45	55	30	20
Mo:	Kansas City	1.33	1.28	100	30	17	16	120	10	45	45	30	<10
	St. Louis	1.35	1.28	55	20	14	12	60	20	45	60	20	10
Mont:	Helena	1.35	1.30	45	25	16	14	80	20	85	90	30	20
Nebr:	Omaha	1.37	1.36	60	25	15	16	90	20	55	60	20	10
Nev:	Las Vegas	1.26	1.19	25	10	6	6	10	<10	40	40	<10	<10
N. H:	Manchester	1.16	1.16	50	5	18	20	40	<10	115	110	10	<10
N. J:	Trenton	1.12	1.14	45	<5	13	14	60	<10	65	65	20	<10
N. Mex:	Albuquerque	1.33	1.28	20	20	5	6	30	10	25	30	20	<10
N. Y:	Buffalo	1.10	1.11	40	10	13	15	40	<10	80	90	10	<10
	New York	1.13	1.09	55	<5	17	16	80	<10	75	70	20	<10
	Syracuse	1.14	1.10	45	<5	14	16	50	<10	65	70	10	<10
N. C:	Charlotte	1.27	1.25	50	25	19	25	20	<10	50	50	20	<10
N. D:	Minot	1.34	1.27	60	15	27	28	60	10	65	90	20	20
Ohio:	Cincinnati	1.16	1.13	60	20	17	18	90	10	45	55	10	<10
	Cleveland	1.16	1.18	50	5	14	15	70	<10	60	60	<10	<10
Okla:	Oklahoma City	1.21	1.24	65	65	17	17	100	30	40	50	20	20
Ore:	Portland	1.40	1.32	150	70	18	12	60	10	80	70	40	30
Pa:	Philadelphia	1.13	1.12	45	10	14	18	80	10	60	70	10	<10
	Pittsburgh	1.14	1.15	55	<5	19	19	110	<10	80	80	20	<10
P. R:	San Juan	1.17	1.24	75	150	10	12	30	30	45	55	10	30
R. I:	Providence	1.11	1.15	45	10	16	14	60	<10	85	80	20	<10
S. C:	Charleston	1.26	1.24	50	60	20	20	40	20	60	65	20	10
S. D:	Rapid City	1.17	1.14	50	25	15	15	70	20	70	85	20	<10
Tenn:	Chattanooga	1.28	1.31	95	70	20	22	60	<10	50	50	30	<10
	Memphis	1.25	1.28	85	95	20	22	80	20	40	45	30	20
Tex:	Austin	1.23	1.24	35	70	8	9	90	30	30	25	20	10
	Dallas	1.23	1.28	90	130	16	18	150	30	45	55	30	20
Utah:	Salt Lake City	1.35	1.31	30	15	11	12	40	20	75	95	30	<10
Vt:	Burlington	1.11	1.15	55	5	13	16	60	<10	85	90	20	<10
Va:	Norfolk	1.23	1.24	45	20	20	18	50	<10	60	60	20	<10
Wash:	Seattle	1.36	1.30	100	35	21	9	60	20	85	75	40	<10
	Spokane	1.40	1.33	35	20	15	13	30	20	80	90	10	<10
W. Va:	Charleston	1.22	1.25	60	15	21	19	40	<10	55	45	20	10
Wis:	Milwaukee	1.18	1.15	45	10	11	9	90	<10	70	65	20	<10
Wyo:	Laramie	1.32	1.28	45	20	12	15	20	10	80	95	10	<10
Network average		1.24	1.23	55	34	15.1	15.4	61	14	62	66	19	<10

200 μμc/liter, while in January 1963 most of the stations reported from <10 to 20 μμc/liter. The Mississippi Valley area was the area with the greatest concentrations during both months. December 1962 iodine-131 concentrations of 100 to 330 μμc/liter were observed in this area while January 1963 averages were from 20 to 40 μμc/liter.

The monthly average strontium-89 concentrations in milk for January 1963 are similar to those in December 1962 in most areas (see figure 3). In January 1963 strontium-89 concentrations generally were below 50 μμc/liter.

Monthly average strontium-90 concentrations in milk for January 1963 were also similar to the ones in December 1962. Most stations reported

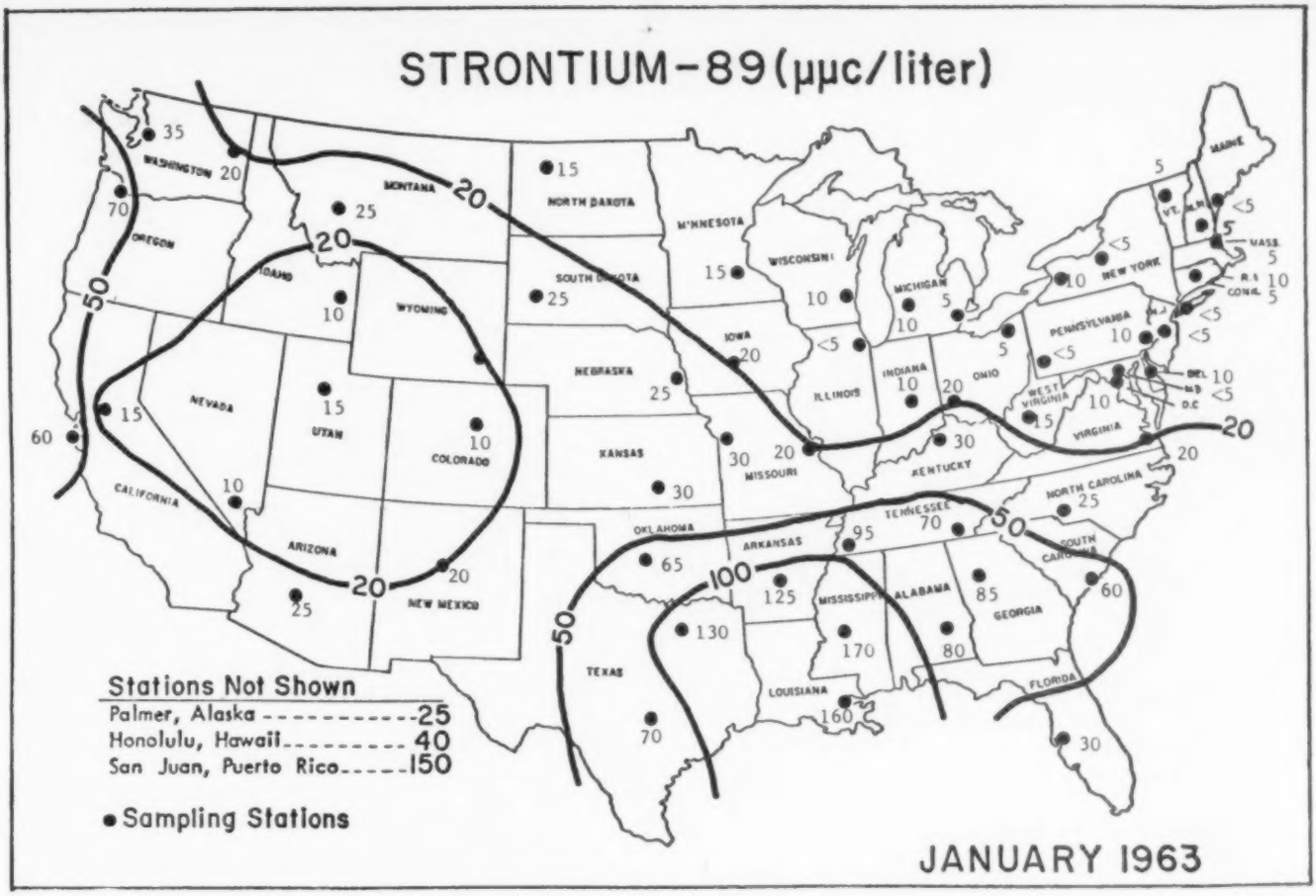

FIGURE 3.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

concentrations from 10 to 20 μμc/liter (see figure 4). In the Southwest, strontium-90 concentrations below 10 μμc/liter were observed, while the lower Mississippi Valley, together with a region extending eastward through the Carolinas to the coast, experienced concentrations of 20 to 30 μμc/liter. North Dakota and Minnesota also experienced approximately this same range of concentrations.

As mentioned previously, radiostrontium levels did not change appreciably since the previous month, but iodine-131 concentrations in milk dropped sharply. Examination of barium-140 and cesium-137 concentrations for December 1962 and January 1963 shows that barium-140 concentrations in milk decreased while cesium-137 concentrations remained approximately constant. In summary, the concentrations of the "long-lived" nuclides remained approximately constant while the concentrations of "short-lived" nuclides decreased from December 1962 to January 1963. Concentrations of strontium-89 ($T_{\frac{1}{2}}$ = 50.5 days) in milk showed a slight decrease.

These observations might be explained by one or more of the following presumptive factors:

1. A relatively low total fallout occurred in January 1963 as compared with December 1962.
2. The relative proportion of short to long-lived radionuclides in January fallout was less than that in December fallout.

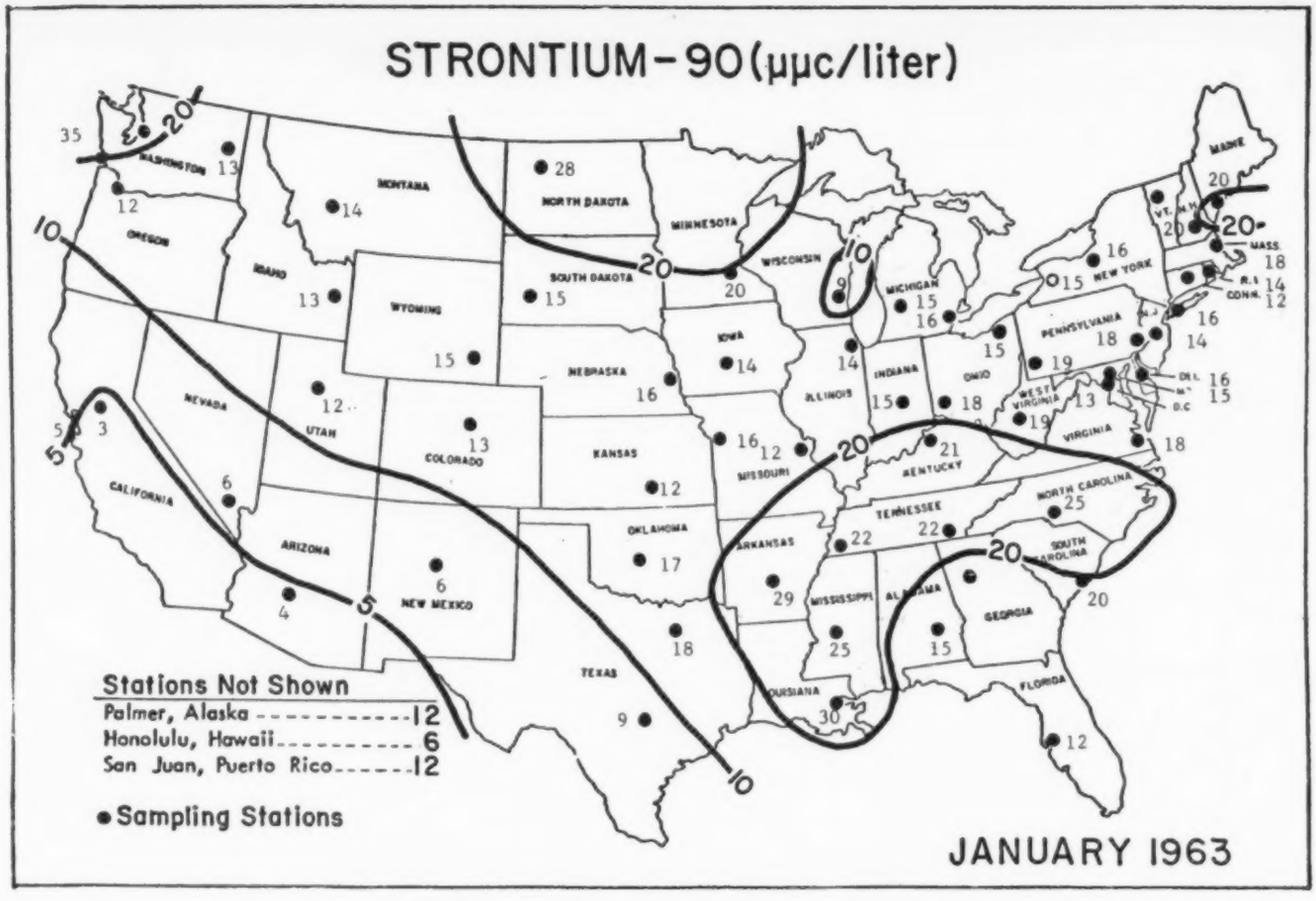

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

3. In January, cows consumed feed which contained relatively little fresh fallout as opposed to December (e.g., relatively more stored feed than pasturage was used).

Deposition data were not available to confirm or disprove that factors 1 and 2 were operative. However, additional information secured concerning factor 3 indicates that, during the first week of January, mild weather permitted livestock throughout the Great Plains Region to feed from Pastures (*1*). In the lower Ohio Valley, the lower Mississippi Valley, and eastward there was limited grazing due to damage to winter pastures. During the latter three weeks of January, snow and low temperature conditions forced cattle from the pasture and pushed supplemental feeding to high levels throughout the nation.

Selected Monthly Strontium-90 Profiles

Continuing the practice of previous issues of *RHD*, figure 5 presents the average monthly strontium-90 concentrations in pasteurized milk from 16 additional cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions.

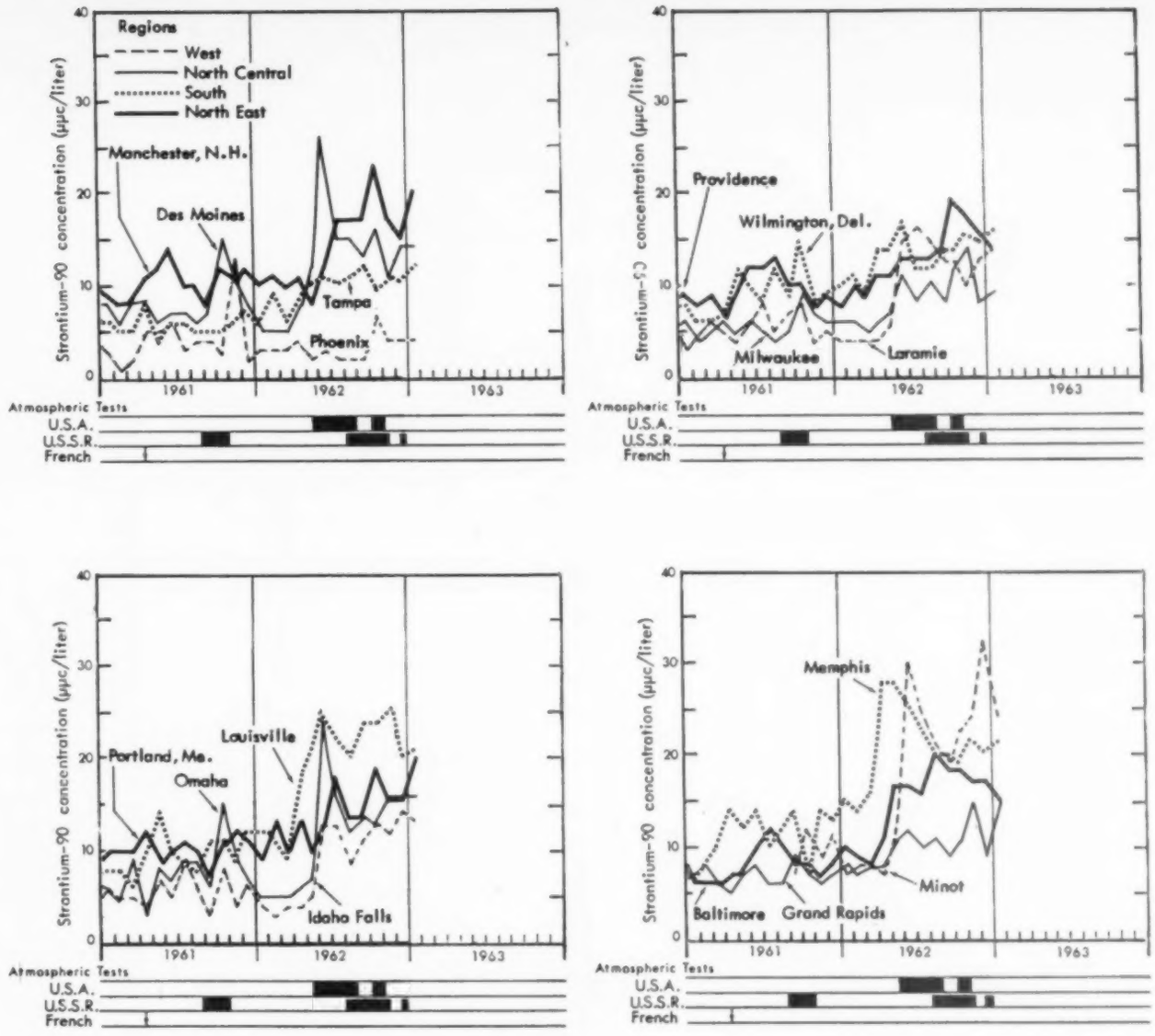

FIGURE 5.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

ANNUAL SUMMARY FOR 1962

The annual average radionuclide concentrations in the Pasteurized Milk Network have been summarized for calendar year 1962 and appear in table 3 below. Included are values for stable calcium and five nuclides of primary importance. Comparable tabular data for 1960 and 1961 have been published previously (*2*).

The annual average values in the table have been compiled from weekly as opposed to monthly averages. This procedure is dictated since each "month", for which monthly radionuclide averages have been published in 1962 contains either four or five weeks depending on the number of full weeks ending within each calendar month. This avoids a possible bias introduced by averaging unequal units of time (months). The year 1962 extends from January 1, 1962 through December 29, 1962. In averaging, when a radionuclide concentration is reported as being below the minimum detectable value, one half of this value is used in the calculations. Where an "average" is determined below this minimum detectable value, the minimum detectable value preceded by a "less than" sign is the reported average.

Figures 6-11 show the geographical distribution of strontium-89 and iodine-131 for 1961 and 1962, and strontium-90 for 1961 and 1962. The values shown on the figures at each station represent the yearly average for that station.

Discussion

The 1960 average for strontium-89 was below the detectable limit since there was no atmospheric nuclear testing since 1958. With the resumed test-

TABLE 3.—ANNUAL SUMMARIES OF RADIOACTIVITY IN PASTEURIZED MILK, 1962

[Average radioactivity concentrations in μμc/liter]

	Sampling locations	Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Ala:	Montgomery[a]	1.21	59	15	18	37	17
Alaska:	Palmer	1.14	51	10	104	37	21
Ariz:	Phoenix	1.13	18	3	12	12	<10
Ark:	Little Rock	1.21	133	29	37	62	27
Calif:	Sacramento	1.15	19	4	12	14	<10
	San Francisco	1.17	32	5	14	17	10
Colo:	Denver	1.17	29	10	15	38	<10
Conn:	Hartford	1.14	22	11	21	45	<10
Del:	Wilmington	1.14	36	13	32	49	<10
D. C:	Washington	1.17	35	14	23	40	11
Fla:	Tampa	1.23	25	10	16	108	<10
Ga:	Atlanta	1.21	84	18	23	57	17
Hawaii:	Honolulu	1.11	27	5	12	27	<10
Idaho:	Idaho Falls	1.14	24	9	25	44	12
Ill:	Chicago	1.14	30	11	38	39	<10
Ind:	Indianapolis	1.17	38	13	33	35	<10
Iowa:	Des Moines	1.15	65	12	59	32	17
Kans:	Wichita	1.15	50	11	59	27	13
Ky:	Louisville	1.19	76	19	29	33	19
La:	New Orleans	1.24	170	30	23	86	29
Maine:	Portland	1.18	30	14	22	75	<10
Md:	Baltimore	1.18	33	15	24	45	10
Mass:	Boston	1.15	31	16	22	76	10
Mich:	Detroit	1.14	27	11	35	44	<10
	Grand Rapids	1.19	23	10	26	42	<10
Minn:	Minneapolis	1.14	55	16	43	58	19
Miss:	Jackson	1.27	154	24	23	56	29
Mo:	Kansas City	1.14	84	14	84	29	25
	St. Louis	1.14	53	13	33	32	17
Mont:	Helena	1.16	44	12	40	50	17
Nebr:	Omaha	1.18	57	13	53	32	15
Nev:	Las Vegas[b]	—	—	—	—	—	—
N. H:	Manchester	1.15	28	14	20	87	<10
N. J:	Trenton	1.13	27	11	22	39	<10
N. Mex:	Albuquerque	1.15	17	4	21	14	12
N. Y:	Buffalo	1.12	24	11	24	50	<10
	New York	1.12	29	14	32	51	<10
	Syracuse	1.14	26	11	27	40	<10
N. C:	Charlotte	1.23	56	19	9	39	13
N. Dak:	Minot	1.15	45	18	41	49	13
Ohio:	Cincinnati	1.16	48	14	39	30	<10
	Cleveland	1.15	29	12	31	38	<10
Okla:	Oklahoma City	1.17	70	17	48	37	18
Ore:	Portland	1.18	82	13	27	53	17
Pa:	Philadelphia	1.15	28	12	29	45	<10
	Pittsburgh	1.15	34	15	40	53	<10
P. R:	San Juan[c]	1.16	71	10	14	40	14
R. I:	Providence	1.14	25	12	23	58	<10
S. C:	Charleston	1.22	68	19	17	56	13
S. Dak:	Rapid City	1.10	54	15	39	46	16
Tenn:	Chattanooga	1.25	117	22	22	56	23
	Memphis	1.22	105	21	27	28	24
Tex:	Austin	1.18	28	7	28	20	10
	Dallas	1.20	76	15	49	34	17
Utah:	Salt Lake City	1.16	30	9	87	52	19
Vt:	Burlington	1.12	30	11	23	58	<10
Va:	Norfolk	1.21	47	17	18	49	11
Wash:	Seattle	1.16	59	15	27	61	18
	Spokane	1.19	36	12	59	49	<10
W. Va:	Charleston	1.18	57	18	19	35	15
Wis:	Milwaukee	1.17	23	8	39	37	<10
Wyo:	Laramie	1.14	52	10	55	56	19
Network average		1.17	50	13.4	32	45	12

[a] Averages for calcium (g/liter) and for barium-140 are for 11 months. No data for February 1962.
[b] No averages are given for Las Vegas since the station has not been in the Pasteurized Milk Network for the entire year.
[c] Averages are for 11 months. No data for November 1962.

ing of nuclear devices in September 1961, strontium-89 reappeared, as shown in the 1961 average values. Most of the U.S. reported averages for strontium-89 of below 20 μμc/liter. The States immediately west of the Mississippi River however, averaged yearly concentrations of strontium-89 of 20 to 30 μμc/liter. In 1962, the concentrations were higher. Most of the country had yearly strontium-89 concentrations of 20 to 101 μμc/liter. The Southwest reported values below 20 μμc/liter, while in the lower Mississippi valley concentrations of 100 to 170 μμc/liter were recorded.

The 1960 average strontium -90 concentrations were 13 μμc/liter throughout the entire country. The Southwest showed a yearly average of below 5 μμc/liter. The resumption of atmospheric nuclear testing did not appreciably increase the yearly average strontium-90 content of milk for 1961.

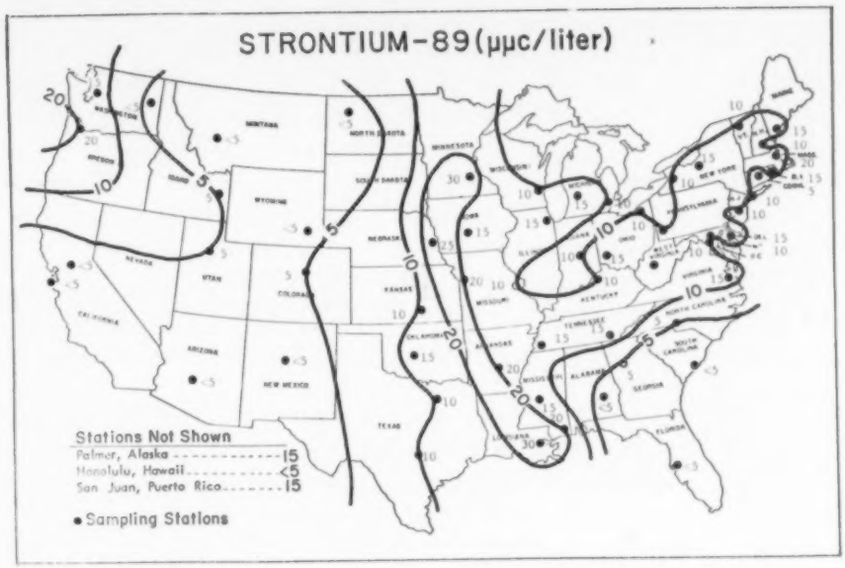

FIGURE 6.—ANNUAL AVERAGE STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, 1961

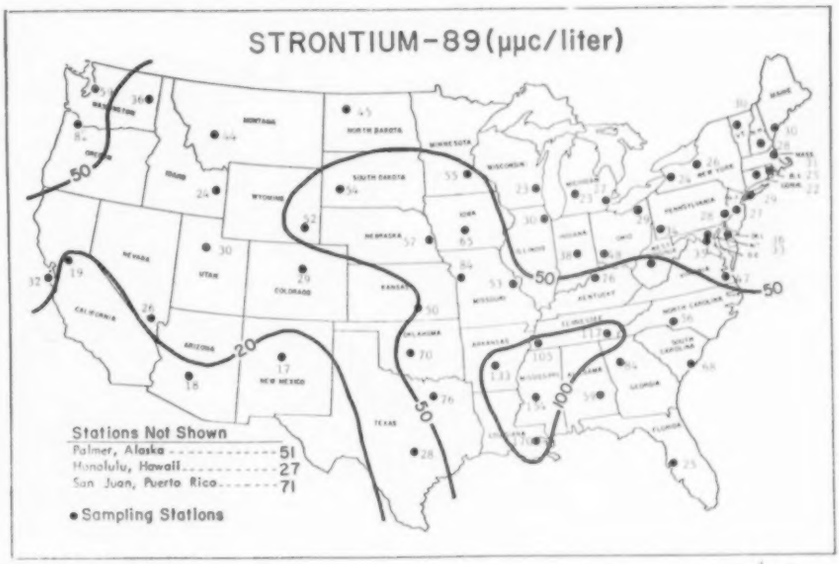

FIGURE 7.—ANNUAL AVERAGE STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, 1962

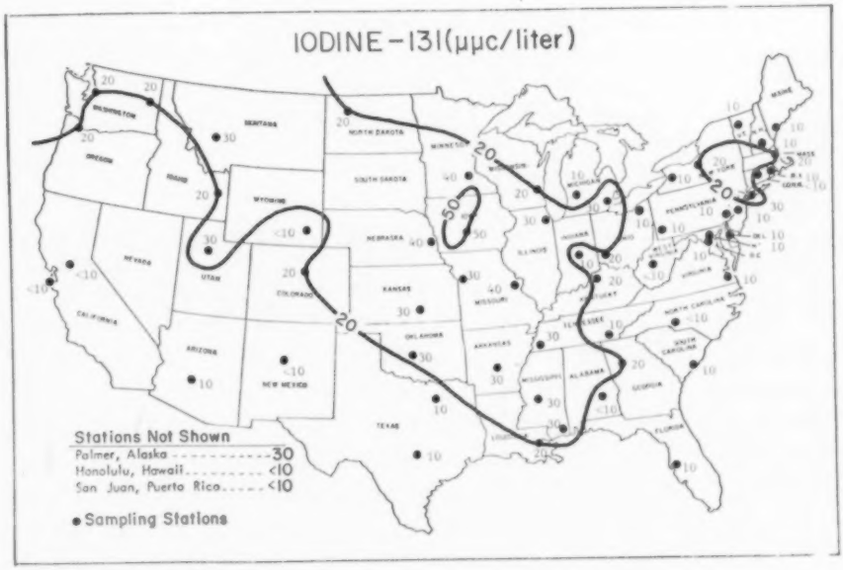

FIGURE 8.—ANNUAL AVERAGE IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK, 1961

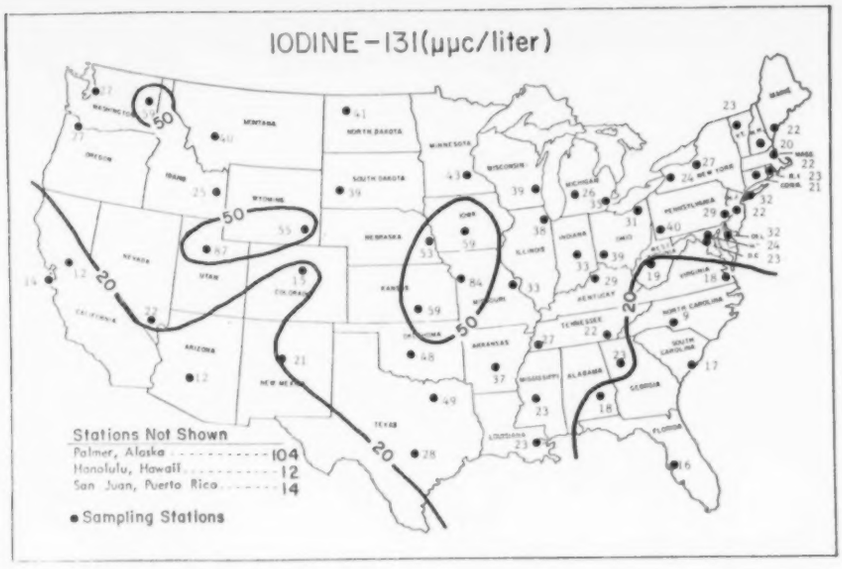

FIGURE 9.—ANNUAL AVERAGE IODINE-131 CONCENTRATIONS IN PASTEURIZED MILK, 1962

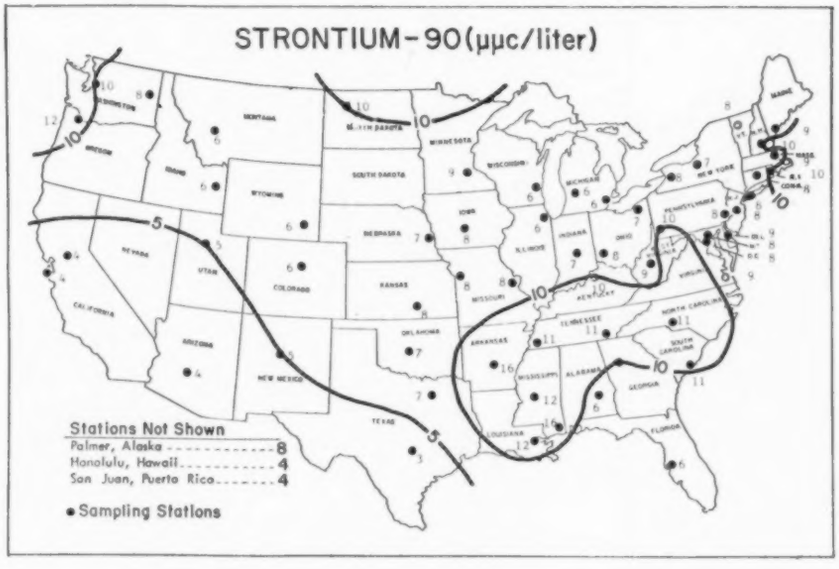

FIGURE 10.—ANNUAL AVERAGE STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1961

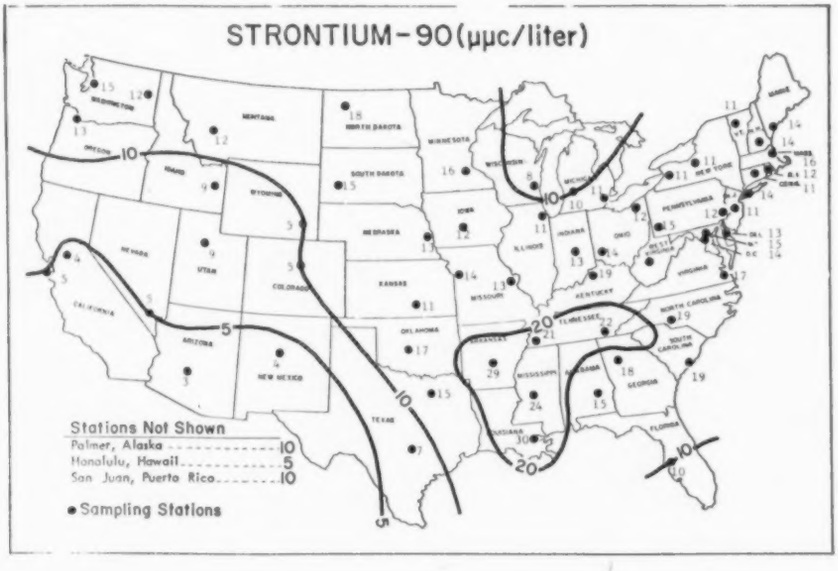

FIGURE 11.—ANNUAL AVERAGE STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1962

The national pattern for 1961 appears similar to that for 1960 with the exception that for 1961 one station had an average concentration of 16 $\mu\mu$c/liter; this was the highest annual average concentration observed that year. In 1962, strontium-90 levels generally increased. The lower Mississippi Valley region exhibited a yearly average concentration of 20 to 30 $\mu\mu$c/liter. Values in the Southwest were below 5 $\mu\mu$c/liter; and the balance of the nation reported values intermediate to these.

Iodine-131 was not detectable in milk in 1960. Iodine-131 appeared in the 1961 average with one station reporting a value of 50 $\mu\mu$c/liter, the highest annual average for that year. In 1962, eight stations reported yearly average iodine-131 levels above 50 $\mu\mu$c/liter, the highest being 104 $\mu\mu$c/ liter. Iodine-131 yearly average concentrations difier markedly from the monthly values. While large excursions in the monthly average concentration of iodine-131 occur at various stations, very large monthly differences between stations and between regions were averaged out over the year.

REFERENCES

(1) United States Department of Agriculture Statistical Reporting Service: *Weekly Weather and Crop Bulletin, Volume L*, Nos. 1-4, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (January 1963, price per year $3.00, price per single copy 10 cents.

(2) Public Health Service; Milk Monitoring Program, *Radiological Health Data*, 3:186-91 (June 1962).

CALIFORNIA MILK NETWORK
July–September 1962

State of California, Department of Public Health

Surveillance of the concentrations of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted since 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation.

The surveillance program involves the weekly sampling of milk from 11 major milksheds (see figure 12). Originally, radioanalyses were performed for potassium-40, cesium-137, and strontium-90 and calcium. More recently, interest has broadened to include not only the above but also iodine-131, strontium-89, and barium-lanthanum-140. All milk is now being analyzed for these three radionuclides only.

FIGURE 12.—CALIFORNIA MILKSHEDS

Results and Discussion

Table 4 presents strontium-89 and strontium-90 monthly averages for the 11 milksheds from July to September 1962. It should be noted that the units used in table 1 are $\mu\mu$c/g calcium. Comparisons of other data in terms of $\mu\mu$c/liter may be made using the approximate equivalent value of 1.1 grams of calcium per liter of milk. No iodine-131 data are given because all samples indicated that iodine-131 concentrations in milk were below the detectable limit of 10 $\mu\mu$c/liter during the third quarter of 1962.

Del Norte and Humboldt Counties have reported milk with higher strontium-89 and strontium-90 concentrations than the other areas. Strontium-90 concentrations in milk have remained relatively constant from July through September, but strontium-89 concentrations underwent a significant decrease from July through August in all milksheds.

TABLE 4.—RADIONUCLIDES IN CALIFORNIA MILK, JULY–SEPTEMBER 1962

[Concentrations in μμc/g calcium]

Sampling area	Strontium-89			Strontium-90		
	July	August	September	July	August	September
Alameda	22.8	2.9	—[a]	3.9	2.3	—
Del Norte	61.4	44.4	50.3	16.8	19.7	13.8
Fresno	9.8	3.7	2.8	3.4	1.8	1.9
Humboldt	20.3	14.1	21.3	4.9	5.6	6.0
Los Angeles	11.2	2.2	2.2	1.5	1.8	2.1
Mendocino	17.8	9.9	4.3	2.9	3.8	3.6
Sacramento	14.1	3.9	3.2	2.4	2.3	1.9
San Diego	12.2	1.5	1.8	1.8	2.3	1.5
Santa Clara	12.3	3.4	1.8	1.9	1.3	2.0
Shasta	24.0	8.6	5.5	3.8	3.6	3.1
Sonoma	13.1	6.0	3.9	2.8	3.1	2.7

[a] Dash indicates no sample.

CONNECTICUT MILK NETWORK
April 1960–December 1962

Connecticut State
Department of Health

The Connecticut State Department of Health began monitoring pasteurized fluid milk for strontium-89 and strontium-90 in April 1960. During this initial period a monthly composite milk sample, representative of the milk sold in the central area of the State, was collected from the processing plant and analyzed for radiostrontium. Beginning in May 1962, the Department's milk monitoring program was expanded to include the determination of iodine-131, barium-lanthanum-140, and cesium-137 in milk samples collected weekly. Since September 1962, the frequency of this sampling has been twice a week.

In addition to sampling milk sold in the central area of the State during 1961, a three-month composite sample representative of the milk sold in the southeastern section of the State was also collected and analyzed for radiostrontium.

From May 1962 to November 1962, weekly samples were collected from milk dealers in five areas of the State (figure 13). These samples, together with the regular composite sample from the central section of the State, were analyzed for the gamma-emitting nuclides. Collection and analysis of these dealer samples will be reinstated when the cows return to pasture feeding in the spring.

A low-background Geiger counter with a thin end-window and gas-flow chamber is used for counting radiostrontium following chemical separation. Initially, the iodine-131, barium-lanthanum-140, and cesium-137 were determined by gamma-scintillation spectrometry using a 4" x 4" sodium iodide crystal and a single-channel analyzer. In November 1962, a 400-channel analyzer was acquired.

TABLE 5.—YEARLY AVERAGES OF STRONTIUM-89 AND STRONTIUM-90 IN MILK FROM CENTRAL AND SOUTHEAST AREAS OF CONNECTICUT, APRIL 1960–DECEMBER 1962

[Concentrations in μμc/liter]

Year	Strontium-89		Strontium-90	
	Central	Southeast	Central	Southeast
April-December 1960	*—	—	8.1	—
1961	6.1	17.2	7.3	10.7
1962	21.0	—	9.4	—

* Dash indicates not detectable.

The 1960, 1961 and 1962 yearly averages of strontium-89 strontium-90 concentrations in milk are given in table 5. The monthly averages for the data obtained from May 1962 through December 1962 are reported in table 6.

TABLE 6.—RADIONUCLIDES IN CONNECTICUT MILK, MAY-DECEMBER 1962

[Concentrations in $\mu\mu c$/liter]

Month	Central area* composite samples					Central area dealer samples			Southeast area dealer samples			Southwest area dealer samples			South central area dealer samples			Northeast area dealer samples		
	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}	I^{131}	Ba-La^{140}	Cs^{137}
May	30	8.0	10	<10	80										<10	10	90			
June	49	14.4	<10	<10	80	<10	10	90				<10	10	90						
July	34	13.9	<10	20	90	<10	<10	100	10	<10	120	<10	10	80						
August	24	11.3	<10	10	70	10	20	80	<10	20	140	<10	10	90				20	<10	110
September	27	11.5	110	20	60	150	40	70	50	40	60	10	10	60				160	30	60
October	34	10.4	90	30	60	80	30	60	70	40	90	80	20	70				70	40	100
November	39	9.5	50	<10	70	60	10	70	120	30	100	60	10	60				100	10	90
December	7.1	8.8	10	<10	70															

* Samples also analyzed by Public Health Service laboratory.

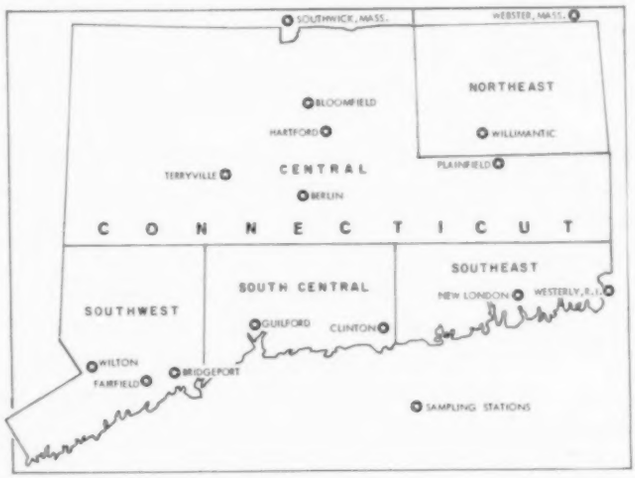

FIGURE 13.—CONNECTICUT MILK SAMPLING STATIONS

yses are performed monthly on samples which are composited from weekly aliquots.

An ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 7. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry* *33*:1306-8 (September 1961).

INDIANA MILK NETWORK
January–February 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 14).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 $\mu\mu c$/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 anal-

FIGURE 14.—INDIANA MILK SAMPLING LOCATIONS

TABLE 7.—RADIONUCLIDES IN INDIANA MILK, JANUARY–FEBRUARY 1963

[Concentrations in $\mu\mu c$/liter]

Sampling location	Strontium–89		Strontium–90		Iodine–131		Cesium–137		Barium-Lanthanum–140	
	January	February[a]	January	February[a]	January	February	January	February	January	February
Evansville	20		17		<10	<10	50	40	<10	<10
Fort Wayne	[b]—		18		<10	<10	50	55	<10	<10
Indianapolis	<10		23		<10	<10	55	50	<10	<10
Rochester	<10		22		<10	<10	55	60	<10	<10
Seymour	<10		24		<10	<10	50	60	<10	<10
State average	10		21		<10	<10	50	55	<10	<10

[a] Available next month.
[b] Dash indicates no sample.

NEW YORK MILK NETWORK
November–December 1962

Division of Special Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities —Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 15), are analyzed for radionuclide content by the State of New York Department of Health. The pasteurized milk samples are collected from processing plants daily and composited weekly for strontium-89, strontium-90, and iodine-131 analyses. The sampling practice at Albany differs in that milk is collected from a marketing point. Also, at Albany and New York City daily samples are analyzed for iodine-131.

In the event that a city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken. The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods to concentrate the strontium, elutriation of strontium isotopes from the ion exchange resin with sodium chloride, gathering by means of sodium carbonate, isolation by means of ethylenediaminetetraacetic acid (EDTA), and counting of radiostrontium with a low background beta counter having a 0.8 mg/cm^2 window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium-90.

Table 8 shows the monthly radionuclide concentration averages for November and December 1962. The numbers in parentheses below the data values are the number of determinations used to compute the monthly average.

REFERENCE

(*1*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Pub. No. 999-R-2.* Single free copies may be obtained from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

FIGURE 15.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 8.—RADIONUCLIDES IN NEW YORK MILK, NOVEMBER–DECEMBER 1962

[Concentrations in pc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137	
	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.
Albany	30	11	11	9	25	<20	65	62
	[a](4)	(4)	(4)	(4)	(25)	(15)	(25)	(15)
Buffalo	30	13	11	8	<20	<20	62	83
	(4)	(2)	(4)	(4)	(6)	(4)	(6)	(4)
Massena	35	15	12	12	<20	<20	117	107
	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Newburgh	51	17	10	8	43	<20	77	52
	(4)	(4)	(4)	(4)	(3)	(4)	(5)	(4)
New York City	46	17	9	10	55	25	[b]—	—
	(5)	(4)	(5)	(4)	(14)	(9)		
Syracuse	21	12	7	6	<20	<20	44	64
	(3)	(4)	(3)	(4)	(3)	(4)	(5)	(4)

[a] Numbers in parentheses indicate the number of samples upon which the monthly average is based.
[b] A dash indicates no sample or no analysis.

OREGON MILK NETWORK
November 1962–February 1963

Division of Sanitation and Engineering
Oregon State Board of Health

Oregon's milk surveillance network was organized in March 1962, by the Oregon State Board of Health in cooperation with the Oregon State Department of Agriculture and Oregon State University. The half-gallon samples of packaged homogenized pasteurized milk are collected on a monthly basis by the Oregon Department of Agriculture and the City of Portland from eight milk districts throughout the State (see figure 16). Sampling on a weekly basis is performed when iodine-131 concentrations in milk exceed 100 pc/liter. The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine-131, cesium-137, and barium-140 analyses. The analyses are performed with a 3" x 3" sodium iodide scintillation crystal and a 512-channel pulse-height analyzer. All milk samples, after being gamma-scanned, are frozen and stored for future strontium-90 analyses.

Table 9 presents the Oregon milk surveillance data for November 1962 through February 1963. The Portland composite sample represents contributions from nearly all milk sheds in Oregon, including some in Washington State. Thus, it tends to represent a State average. Tillamook has

FIGURE 16.—OREGON PASTEURIZED MILK NET WORK SAMPLING LOCATIONS

shown the highest concentrations with a maximum iodine-131 concentration for a single sample of 530 pc/liter on November 12, 1962. The frequency of sampling at Tillamook was temporarily increased to a weekly rate when concentrations exceeded 100 pc/liter. A review of the values obtained at Tillamook established that the iodine concentrations decreased at a rate corresponding to an 8-day half-life. This indicated an apparent single intrusion of fission products, rather than a continuous contribution from the atmosphere. The Tillamook and Coos Bay samples tend to be higher than other locations, probably due to the greater

yearly precipitation along the Pacific Coast compared to the inland areas.

To maintain a check on the analytical procedures and instrument calibration, a split sample of the official U.S. Public Health Service pasteurized milk sample from Portland is obtained on a weekly basis for analysis. These data are compared to the Public Health Service data in figure 17.

TABLE 9.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, NOVEMBER 1962–FEBRUARY 1963

[Average concentrations in pc/liter]

Sampling location	Number of samples analyzed				Iodine-131				Cesium-137				Barium-140			
	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.
Baker	1	1	1	1	<15	30	<15	<15	45	50	40	45	<15	<15	<15	<15
Coos Bay	0	2	1	1	—	60	30	30	—	110	110	110	—	70	<15	<15
Eugene	1	1	1	1	50	15	<15	<15	45	50	45	65	<15	<15	<15	<15
Medford	1	1	1	1	40	<15	<15	<15	35	35	30	45	<15	<15	<15	<15
Nyssa	1	1	1	1	20	15	<15	<15	35	90	40	30	<15	<15	<15	<15
Portland (composite)	4	5	4	3	110	40	15	<15	90	75	60	70	40	<15	<15	<15
Portland (local producer)	4	5	4	3	40	15	15	<15	70	70	70	65	20	<15	<15	<15
Redmond	1	1	1	1	80	<15	15	<15	40	30	35	60	<15	<15	<15	<15
Tillamook	4	2	1	1	390	100	30	<15	245	155	115	80	220	60	<15	<15

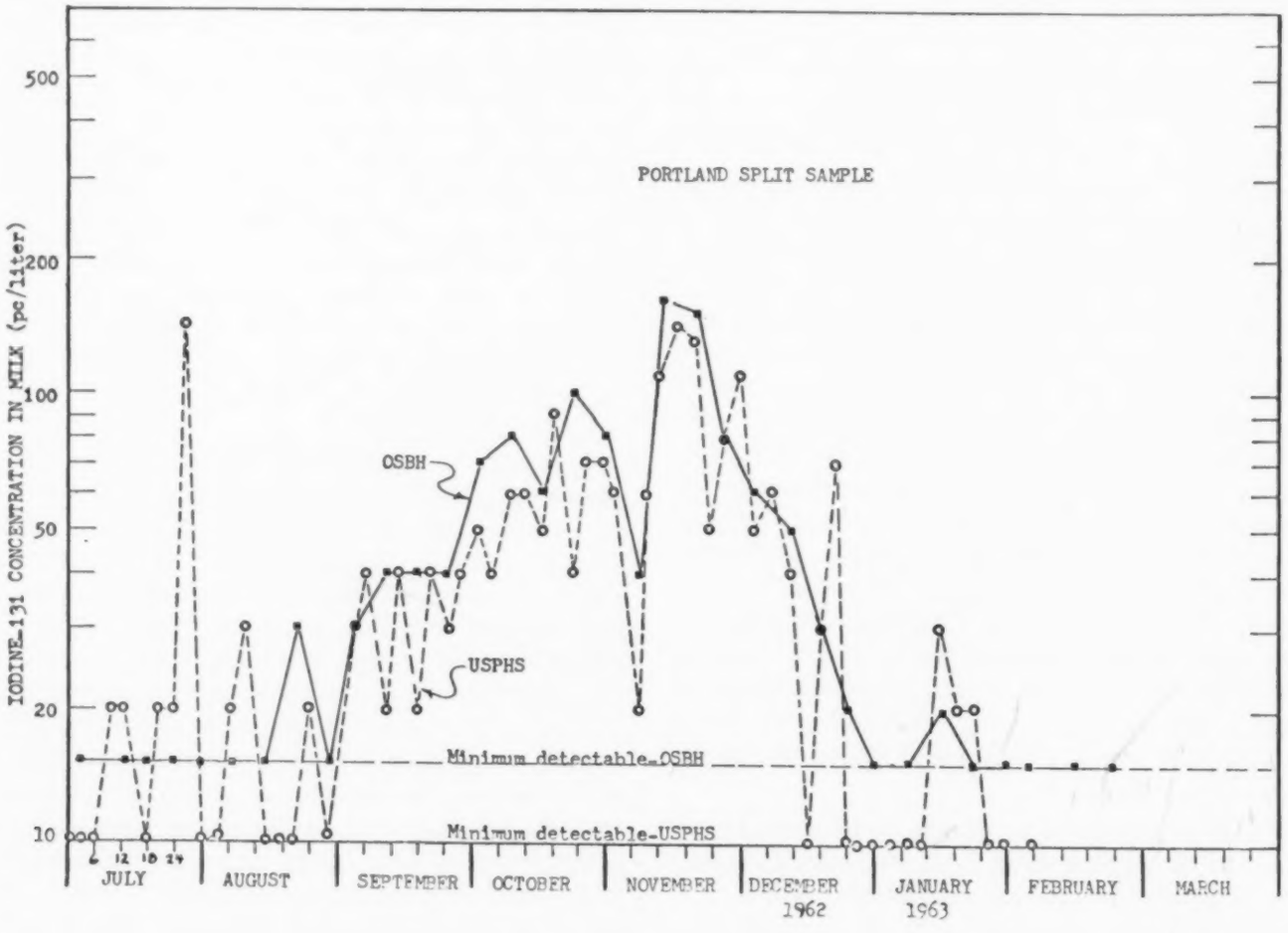

FIGURE 17.—COMPARISON OF PUBLIC HEALTH SERVICE AND OREGON STATE BOARD OF HEALTH MILK ANALYSES FOR PORTLAND

CANADIAN MILK NETWORK
December 1962

Radiation Protection Division
Department of National Health and
Welfare, Ottawa, Canada

Dried Milk Products

Beginning in November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium-90 concentrations were initiated by the Department of National Health and Welfare. Since April 1962, analyses for strontium-89 and cesium-137 have also been included.

Samples are collected through the cooperation of the Dairy Products Division of the Canadian Department of Agriculture, whose inspectors pick up four 1-pound samples of dried milk from each station (see figure 18) on a monthly schedule.

No statistical plan is followed for sample collection. Because of uncertainties introduced by this method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. However, it is possible to consider all results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figures 19 and 20.

FIGURE 18.—CANADIAN MILK SAMPLING STATIONS

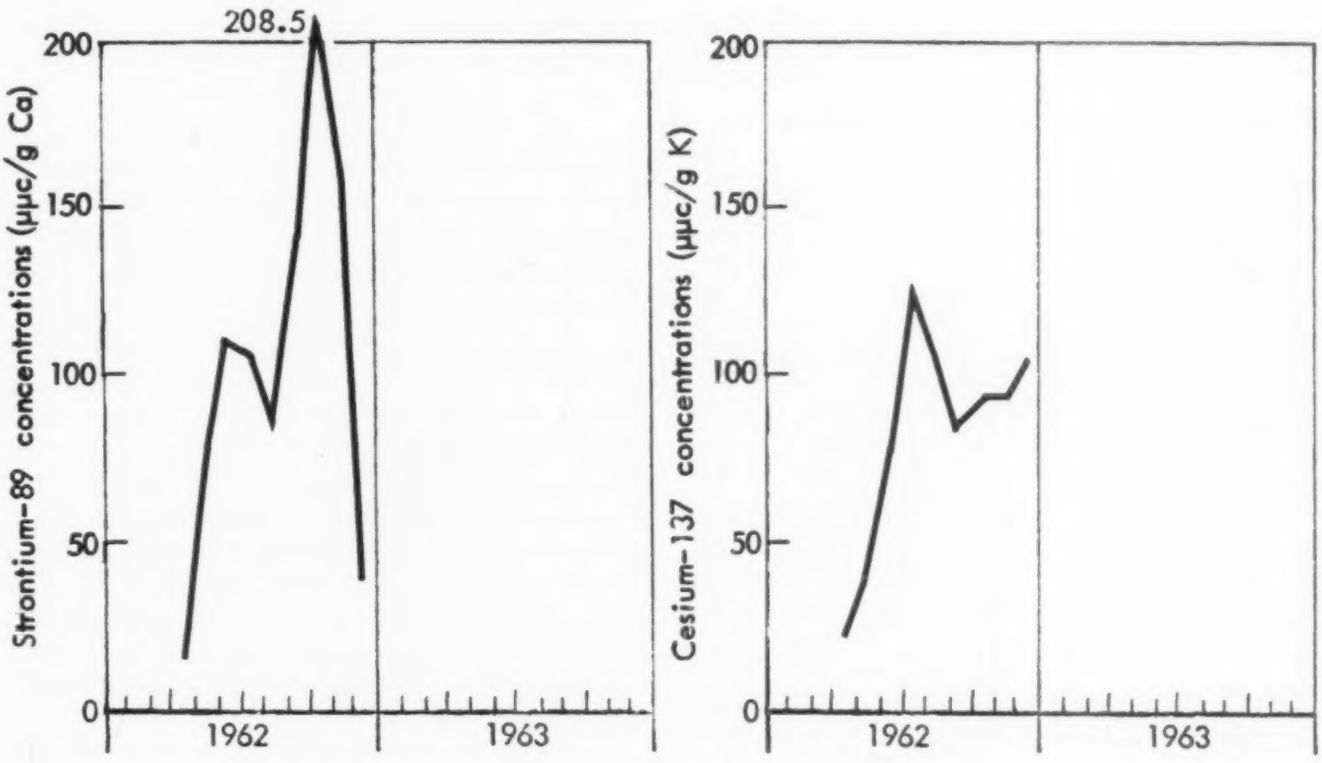

FIGURE 19.—AVERAGE STRONTIUM-89 AND CESIUM-137 CONCENTRATIONS IN MILK POWDER

A detailed discussion of the sampling and radiochemical procedures employed may be found in the Department's publications (*1*, *2*). Table 10 presents the results of measurements of strontium-89. strontium-90, and cesium-137 in Canadian dried milk powder for December 1962. These data were taken from the "Data from Radiation Protection Programs," dated February 1963, published by the Radiation Protection Division of the Department of National Health and Welfare.

TABLE 10.—RADIONUCLIDES IN CANADIAN DRIED MILK POWDER, DECEMBER 1962

Station	Strontium-89 (μμc/g Ca)	Strontium-90 (μμc/g Ca)	Cesium-137 (μμc/g K)
Arborg	[a]—	—	—
Calgary	86.8	40.8	90
E. Florenceville	—	—	—
Edmonton	62.9	25.3	87
Grunthal	28.3	17.0	58
Halifax	18.9	19.0	103
La Durantaye	24.5	39.6	162
Lawrenceville	19.7	25.5	118
London	17.9	10.4	58
Megantic	15.6	40.3	161
Moncton	17.4	31.5	140
Nicolet	19.2	21.2	78
Ottawa	23.6	20.0	—
Saskatoon	102.4	18.9	59
Sussex	77.8	59.8	131
Vancouver	52.1	25.2	115
Walkerton	20.8	11.8	68
Average	39.2	27.1	102

[a] Dash indicates no sample.

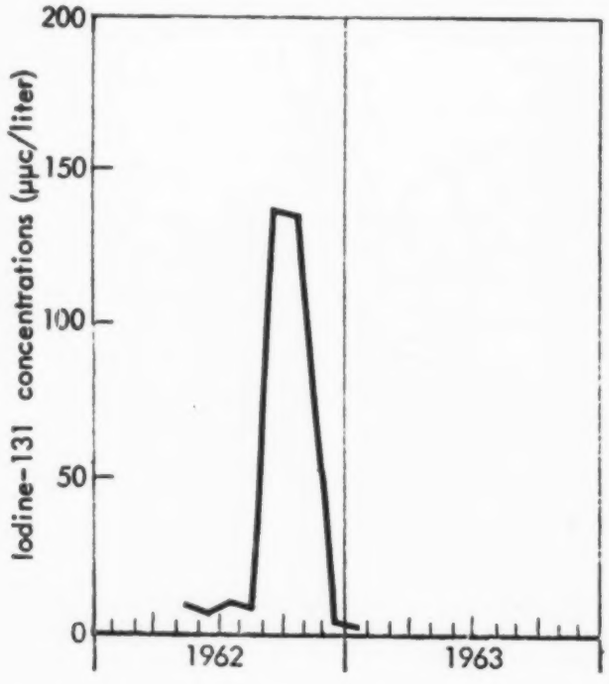

FIGURE 20.—IODINE-131 CONCENTRATIONS IN WHOLE MILK

During 1962, there has been almost a continual increase in the national average strontium-90 concentrations from the low of 6.9 μμc/g calcium in March to 32.7 μμc/g calcium in November (see figure 21). In December, the national average decreased to 27.1 μμc/g calcium. However, the national average for 1962 was 19.4 μμc/g calcium.

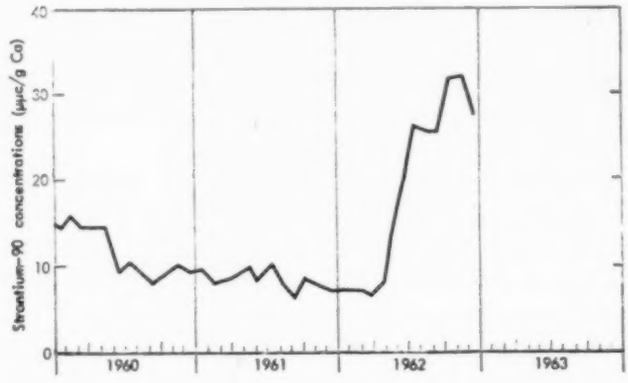

FIGURE 21.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

The national average strontium-89 concentration in powdered milk dropped to 27.1 μμc/g calcium in December. As shown in figure 19 there is quite a pronounced peak in the national average strontium-89 concentrations in 1962.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g calcium to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1.2 g calcium/liter of liquid milk. Canadian powdered milk data may be compared to liquid milk data by multiplying the former values by 1.2.

Whole Milk

In April 1962, monitoring of liquid whole milk for iodine-131 was begun. Table 11 presents the December 1962 and January 1963 average concentrations of iodine-131 in liquid whole milk for nine cities. It may be noted that the national average which increased during the fall of 1962 has decreased to 7 μμc/liter in December 1962 and has remained low (3 μμc/liter) during January 1963 (see figure 20) indicating very little fresh fallout entering the milk.

It should be emphasized again that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium

TABLE 11.—IODINE-131 IN CANADIAN LIQUID WHOLE MILK

[Concentrations in $\mu\mu c$/liter]

Station	December 1962	January 1963
Calgary	9 (12)[a]	5 (13)
Halifax	10 (10)	3 (12)
Ottawa	5 (10)	2 (13)
Quebec	7 (11)	4 (13)
Saskatoon	4 (10)	4 (13)
Sault Ste. Marie	8 (11)	3 (12)
Vancouver	8 (10)	2 (13)
Windsor	12 (7)	5 (13)
Winnipeg	3 (12)	2 (13)
Average	7	3

[a] Numbers in parentheses indicate the number of samples on which the monthly average is based.

with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW (RPD-1)* (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, (RPD-5)*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

MEXICAN MILK NETWORK
November–December 1962

Radiological Protection Program of the National Commission of Nuclear Energy, Mexico

The Pasteurized Milk Monitoring Program of Mexico was established in March 1962 by the "Comision National de Energia Nuclear" through its Radiological Protection Program to provide a means for estimating the ingestion of strontium-90 from milk.

Milk has been analyzed from twelve cities distributed throughout Mexico. Since each city is supplied from a large number of sources, it has not been possible, to date, to apply a representative sampling method. However, samples from at least four main sources that supply large population groups were collected in each city.

The results presented in table 12 give an estimation of the strontium-90 content of the milk consumed in Mexico.

TABLE 12.—STRONTIUM-90 IN MEXICAN PASTEURIZED MILK, NOVEMBER-DECEMBER 1962

[Monthly averages]

Month (1962)	Sampling location	Calcium (g/liter)	Strontium-90 ($\mu\mu c$/liter)	Strontium-90 ($\mu\mu c$/g Ca)
November	México, D. F.[a]	1.07	2.9	2.7
	Puebla	1.13	1.5	1.4
	Poza Rica	1.15	1.1	1.0
December	México, D. F.	1.16	1.35	1.2
	Casas Grandes	1.10	2.6	2.4
	Tuxtla Gutierrez	1.12	1.0	1.0
	Villahermosa	1.38	4.1	3.0

[a] México City.

Twelve Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: March 1962–February 1963
Strontium-89 and strontium-90:
February 1962–January 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges as proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3,*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. They present index values which are the estimated sum of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the second column in table 1 gives the iodine-131 February 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. Yearly index values are obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (B) to those in column (A) and subtracting those in (C).

For a number of reasons it is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6-18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159-65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii-iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1962).

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[$\mu\mu$c day/liter][a]

Sampling locations		Feb. 1963 iodine-131 averages ($\mu\mu$c/liter)	Iodine-131 index value			
			Feb 1962-Jan 1963 (A)	Feb 1963 (B)	Jan 27, 1963-Feb 23, 1963 (C)	Mar 1962-Feb 1963 (D)
Ala:	Montgomery	<10	6,590	140	140	6,590
Alaska:	Palmer	<10	38,220	140	140	38,220
Ariz:	Phoenix	<10	4,270	140	140	4,270
Ark:	Little Rock	20	14,250	140	560	14,670
Calif:	Sacramento	<10	5,050	140	140	5,050
	San Francisco	<10	4,940	140	140	4,940
Colo:	Denver	<10	5,860	280	140	5,720
Conn:	Hartford	<10	7,670	140	140	7,670
Del:	Wilmington	10	11,730	140	280	11,870
D. C:	Washington	<10	8,440	140	140	8,440
Fla:	Tampa	20	6,240	140	560	6,660
Ga:	Atlanta	10	8,900	140	280	9,040
Hawaii:	Honolulu	20	4,830	140	560	5,250
Idaho:	Idaho Falls	<10	9,660	560	140	9,240
Ill:	Chicago	<10	13,690	140	140	13,690
Ind:	Indianapolis	<10	12,010	140	140	12,010
Iawa:	Des Moines	<10	21,840	140	140	21,840
Kans:	Wichita	<10	21,740	140	140	21,740
Ky:	Louisville	<10	10,540	140	140	10,540
La:	New Orleans	30	8,900	140	840	9,600
Maine:	Portland	<10	8,160	140	140	9,160
Md:	Baltimore	<10	8,690	140	140	8,690
Mass:	Boston	<10	7,950	140	140	7,950
Mich:	Detroit	<10	12,820	140	140	12,820
	Grand Rapids	10	9,420	140	280	9,560
Minn:	Minneapolis	<10	16,170	140	140	16,170
Miss:	Jackson	20	9,110	140	560	9,530
Mo:	Kansas City	<10	30,380	280	140	30,240
	St. Louis	<10	12,530	140	140	12,530
Mont:	Helena	10	14,910	560	280	14,630
Nebr:	Omaha	<10	19,530	280	140	19,390
Nev:	Las Vegas	<10	[b]4,100	[c]—	140	[b]4,240
N. H:	Manchester	20	7,290	140	560	7,710
N. J:	Trenton	<10	7,990	140	140	7,990
N. Mex:	Albuquerque	<10	7,460	560	140	7,040
N. Y:	Buffalo	<10	8,720	140	140	8,720
	New York	<10	11,660	140	140	11,660
	Syracuse	<10	9,980	140	140	9,980
N. C:	Charlotte	<10	3,370	140	140	3,370
N. Dak:	Minot	<10	14,910	140	140	14,910
Ohio:	Cincinnati	10	14,460	140	280	14,600
	Cleveland	<10	11,100	140	140	11,100
Okla:	Oklahoma City	10	18,240	140	280	18,380
Ore:	Portland	<10	9,770	140	140	9,770
Pa:	Philadelphia	<10	10,820	140	140	10,820
	Pittsburgh	10	14,670	140	280	14,810
P. R:	San Juan	30	[d]5,260	140	840	[d]5,960
R. I:	Providence	10	8,440	140	280	8,580
S. C:	Charleston	20	6,590	140	560	7,010
S. Dak:	Rapid City	10	14,530	140	280	14,670
Tenn:	Chattanooga	<10	7,850	140	140	7,850
	Memphis	<10	10,050	140	140	10,050
Tex:	Austin	<10	11,040	140	140	11,040
	Dallas	20	18,420	140	560	18,840
Utah:	Salt Lake City	10	31,920	280	280	31,920
Vt:	Burlington	<10	8,380	140	140	8,380
Va:	Norfolk	<10	6,410	140	140	6,410
Wash:	Seattle	<10	9,940	140	140	9,940
	Spokane	10	21,770	140	280	21,910
W. Va:	Charleston	10	6,830	140	280	6,970
Wis:	Milwaukee	10	14,320	140	280	14,460
Wyo:	Laramie	<10	19,850	280	140	19,710

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index ($\mu\mu$c day/liter) × milk consumption factor (liter/day/person) = 12-month I^{131} intake ($\mu\mu$c/person)

[b] Station included in milk network in July 1962. The sums in column A and D are therefore for 7 and 8 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. These sums are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values ($\mu\mu$c day/liter)[a]				Strontium-90 index values ($\mu\mu$c day/liter)[a]			
		Jan. 1962-Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962-Jan. 26, 1963 (C)	Feb. 1962-Jan. 1963 (D)	Jan. 1962-Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962-Jan. 26, 1963 (C)	Feb. 1962-Jan. 1963 (D)
Ala:	Montgomery	21,385	70	2,240	23,555	5,324	270	420	5,474
Alaska:	Palmer	18,665	270	700	19,095	3,607	135	336	3,808
Ariz:	Phoenix	6,570	810	700	6,460	1,145	81	112	1,176
Ark:	Little Rock	48,215	1,350	3,500	50,365	10,661	567	812	10,906
Calif:	Sacramento	6,905	270	420	7,055	1,363	54	84	1,393
	San Francisco	11,610	270	1,680	13,020	1,895	54	140	1,981
Colo:	Denver	10,435	405	280	10,310	3,529	162	364	3,731
Conn:	Hartford	8,000	70	140	8,070	3,861	270	336	3,927
Del:	Wilmington	12,985	70	280	13,195	4,799	270	448	4,977
D. C:	Washington	12,550	70	280	12,760	5,164	243	364	5,285
Fla:	Tampa	8,980	405	840	9,415	3,459	162	336	3,633
Ga:	Atlanta	30,580	2,160	2,380	30,800	6,401	297	504	6,608
Hawaii:	Honolulu	9,870	945	1,120	10,045	1,858	108	168	1,918
Idaho:	Idaho Falls	8,730	135	280	8,875	3,230	108	364	3,486
Ill:	Chicago	10,800	70	70	10,800	3,886	162	392	4,116
Ind:	Indianapolis	13,720	70	280	13,930	4,772	243	420	4,949
Iowa:	Des Moines	23,670	270	560	23,960	4,461	135	392	4,718
Kans:	Wichita	18,185	405	840	18,620	4,096	162	336	4,270
Ky:	Louisville	27,640	270	840	28,210	7,030	324	588	7,294
La:	New Orleans	61,790	8,100	4,480	58,170	10,854	648	840	11,046
Maine:	Portland	10,800	70	70	10,800	4,982	243	560	5,299
Md:	Baltimore	11,815	70	70	11,815	5,404	280	420	5,544
Mass:	Boston	11,290	70	140	11,360	5,731	243	504	5,992
Mich:	Detroit	9,785	70	140	9,855	3,956	162	448	4,242
	Grand Rapids	8,350	70	280	8,560	3,590	216	420	3,794
Minn:	Minneapolis	20,135	270	420	20,285	5,818	162	560	6,216
Miss:	Jackson	55,930	5,670	4,760	55,020	8,740	648	700	8,792
Mo:	Kansas City	30,505	405	840	30,940	5,145	189	448	5,404
	St. Louis	19,100	270	560	19,390	4,843	216	336	4,963
Mont:	Helena	16,025	135	700	16,590	4,203	108	392	4,487
Nebr:	Omaha	20,740	405	700	21,035	4,576	135	448	4,889
Nev:	Las Vegas	[b]4,760	[c]—	280	[b]5,040	[b]994	—	168	[b]1,162
N. H:	Manchester	10,345	70	140	10,415	5,072	270	560	5,362
N. J:	Trenton	9,925	70	70	9,925	3,982	216	392	4,158
N. Mex:	Albuquerque	6,165	540	560	6,185	1,611	162	168	1,617
N. Y:	Buffalo	8,770	70	280	8,980	4,105	297	420	4,228
	New York	10,555	70	70	10,555	4,951	324	448	5,075
	Syracuse	9,555	70	70	9,555	3,942	162	448	4,228
N. C:	Charlotte	20,360	270	700	20,790	6,856	297	700	7,259
N. Dak:	Minot	16,370	135	420	16,655	6,699	189	784	7,294
Ohio:	Cincinnati	17,355	135	560	17,780	5,247	270	504	5,481
	Cleveland	10,660	70	140	10,730	4,234	216	420	4,438
Okla:	Oklahoma City	25,440	1,080	1,820	26,180	5,997	243	476	6,230
Ore:	Portland	29,605	1,080	1,960	30,485	4,879	189	336	5,026
Pa:	Philadelphia	10,205	70	280	10,415	4,493	216	504	4,781
	Pittsburgh	12,215	70	70	12,215	5,546	324	532	5,754
P. R:	San Juan	[b]23,920	3,375	4,200	[b]24,745	[b]3,329	270	336	[b]3,395
R. I:	Providence	8,980	70	280	9,190	4,521	216	392	4,697
S. C:	Charleston	24,720	1,620	1,680	24,780	6,832	378	560	7,014
S. Dak:	Rapid City	19,785	270	700	20,215	5,482	162	420	5,740
Tenn:	Chattanooga	42,435	1,485	1,960	42,910	7,851	270	616	8,197
	Memphis	38,185	2,835	2,660	38,010	7,587	405	616	7,798
Tex:	Austin	10,235	540	1,960	11,655	2,558	108	252	2,702
	Dallas	27,715	1,080	3,640	30,275	5,305	216	504	5,593
Utah:	Salt Lake City	10,935	135	420	11,220	3,166	135	336	3,367
Vt:	Burlington	10,970	135	140	10,975	4,066	216	448	4,298
Va:	Norfolk	17,105	270	560	17,395	6,345	297	504	6,552
Wash:	Seattle	21,505	540	980	21,945	5,433	162	252	5,523
	Spokane	13,105	135	560	13,530	4,453	162	364	4,655
W. Va:	Charleston	20,785	135	420	21,070	6,591	270	532	6,853
Wis:	Milwaukee	8,245	70	280	8,455	3,046	162	252	3,136
Wyo:	Laramie	18,740	135	560	19,165	3,552	108	420	3,864

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value ($\mu\mu$c day/liter) × milk consumption factor (liter/day/person) = 12-month intake ($\mu\mu$c/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are for 6 and 7 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. These sums are therefore fo 11 months.

SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
November 1962

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been under surveillance by the Public Health Service through the National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the the establishment of 50 sampling points, this network has been expanded as of March 1963, to 125 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations, samples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. The samples are then analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*1,3*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*4*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*5, 6*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples.

FIGURE 1.—TOTAL BETA ACTIVITY ($\mu\mu$c/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, NOVEMBER 1962

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1962

[Average concentrations in pc/liter]

Station	November 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	—	—	—	—	—	—
Animas River: Cedar Hill, N. Mex	283	37	320	9	3	12
Apalachicola River: Chattahoochie, Fla	3	12	15	0	0	0
Arkansas River:						
Coolidge, Kans	91	146	237	2	39	41
Ponca City, Okla	32	39	71	1	3	4
Bear River: Preston, Idaho	9	25	34	<1	2	2
Bighorn River: Hardin, Mont	16	32	48	2	6	8
Sioux River: Sioux Falls, S. Dak	11	42	53	—	—	—
Chattahoochie River:						
Atlanta, Ga	9	17	26	1	0	1
Columbus, Ga	17	18	35	1	0	1
Lanett, Ala	22	12	34	1	0	1
Chena Slough: Fairbanks, Alaska	10	21	31	0	1	1
Clear Water River: Lewiston, Idaho	12	14	26	0	0	0
Clinch River:						
Kingston, Tenn	—	—	—	—	—	—
Clinton, Tenn	5	18	23	0	<1	<1
Colorado River:						
Loma, Colo	59	40	99	2	8	10
Page, Ariz	108	34	142	21	7	28
Boulder City, Nev	0	15	15	0	9	9
Parker Dam, Calif.-Ariz	—	—	—	—	—	—
Yuma, Ariz	37	109	146	0	10	10
Columbia, River:						
Northport, Wash	5	18	23	0	<1	<1
Wenatchee, Wash	0	10	10	1	2	3
Pasco, Wash	28	544	572	0	1	1
McNary Dam, Ore	17	183	200	0	1	1
Bonneville, Ore	22	122	144	0	1	1
Clatskanie, Ore	101	81	182	0	0	0
Connecticut River:						
Wilder, Vt	8	19	27	0	<1	<1
Northfield, Mass	7	19	26	0	0	0
Enfield Dam, Conn	8	16	24	0	<1	<1
Delaware River:						
Martins Creek, Pa	7	23	30	0	0	0
Trenton, N. J	12	22	34	0	0	0
Philadelphia, Pa	16	24	40	0	0	0
Escambia River: Century, Fla	—	—	—	—	—	—
Great Lakes:						
Duluth, Minn	5	5	10	0	0	0
Sault Ste. Marie, Mich	3	8	11	0	0	0
Milwaukee, Wis	1	14	15	0	0	0
Gary, Ind	1	13	14	0	0	0
Port Huron, Mich	6	22	28	0	0	0
Detroit, Mich	3	19	22	0	0	0
Buffalo, N. Y	4	6	10	0	0	0
Green River: Dutch John, Utah	27	29	56	0	2	2
Hudson River: Poughkeepsie, N. Y	12	135	147	1	0	1
Illinois River:						
Peoria, Ill	5	24	29	1	1	2
Grafton, Ill	24	29	53	1	0	1
Kanawha River: Winfield Dam, W. Va	19	17	36	1	0	1
Klamath River: Keno, Ore	8	18	26	0	0	0
Little Miami River: Cincinnati, Ohio	14	38	52	0	1	1
Merrimack River: Lowell, Mass	9	67	76	0	0	0
Mississippi River:						
St. Paul, Minn	9	31	40	0	0	0
Dubuque, Iowa	27	29	56	0	0	0
Burlington, Iowa	310	24	334	0	0	0
E. St. Louis, Ill	9	37	46	0	1	1
Cape Girardeau, Mo	20	48	68	1	2	3
W. Memphis, Ark	56	28	84	0	2	2
Delta, La	—	—	—	—	—	—
New Orleans, La	10	31	41	1	3	4
Vicksburg, Miss	25	33	58	2	1	3
Missouri River:						
Williston, N. Dak	9	17	26	1	4	5
Bismarck, N. Dak	2	18	20	1	4	5
Yankton, S. Dak	3	50	53	0	4	4
Omaha, Nebr	13	22	35	2	4	6
St. Joseph, Mo	18	45	63	3	10	13
Kansas City, Kans	26	30	56	2	7	9
St. Louis, Mo	—	—	—	—	—	—
Missouri City, Mo	38	44	82	7	9	16
Monongahela River: Pittsburgh, Pa	3	22	25	0	1	1
North Platte River: Henry, Nebr	10	45	55	1	23	24
Ohio River:						
E. Liverpool, Ohio	1	13	14	0	0	0
Addison, Ohio	6	26	32	<1	1	1
Huntington, W. Va	41	31	72	2	0	2
Cincinnati, Ohio	15	26	41	1	1	2
Louisville, Ky	34	24	58	1	0	1
Evansville, Ind	34	34	68	1	0	1
Cairo, Ill	21	19	40	6	1	7
Ouchita River: Bastrop, La	4	16	20	0	1	1
Pend Oreille River: Albeni Falls Dam, Idaho	13	36	49	0	<1	<1
Platte River: Plattsmouth, Nebr	23	41	64	2	6	8

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1962—Continued

[Average concentrations in pc/liter]

Station	November 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Potomac River:						
Williamsport, Md	20	15	35	0	0	0
Great Falls, Md	29	80	109	1	0	1
Rainy River:						
Baudette, Minn	9	31	40	0	0	0
International Fls, Minn	4	20	24	<1	0	<1
Red River: Grand Forks, N. Dak	1	33	34	—	—	—
Red River, South:						
Denison, Tex	36	41	77	0	1	1
Index, Ark	43	46	89	1	1	2
Alexandria, La	122	31	153	4	0	4
Bossier City, La	297	79	376	7	8	15
Rio Grande River:						
Alamaso, Colo	16	18	34	1	0	1
El Paso, Tex	22	39	61	1	6	7
Laredo, Tex	110	51	161	—	—	—
Brownsville, Tex	6	16	22	1	5	6
Roanoke River: John H. Kerr Resr. & Dam, Va	7	19	26	0	0	0
Sabine River: Rubliff, Tex	—	—	—	—	—	—
Sacramento River:						
Greens Landing, Courtland, Calif	13	15	28	1	1	2
San Joaquin River: Vernalis, Calif	31	24	55	1	3	4
San Juan River: Shiprock, N. Mex	95	51	146	11	6	17
St. Lawrence River: Massena, N. Y	24	23	47	0	0	0
Schuylkill River, Philadelphia, Pa	26	20	46	1	0	1
Savanah River:						
North Augusta, Ga	3	8	11	0	0	0
Port Wentworth, Ga	7	25	32	0	0	0
Shenandoah River: Berryville, Va	14	30	44	<1	1	1
Ship Creek: Anchorage, Alaska	0	7	7	0	0	0
Snake River:						
Ice Harbor Dam, Wash	7	23	30	<1	2	2
Wawawai, Wash	—	—	—	—	—	—
Payette, Idaho	9	29	38	<1	2	2
South Platte River: Julesburg, Colo	28	178	206	2	28	30
Spokane River: Post Falls, Idaho	12	12	24	0	0	0
Susquehanna River:						
Sayre, Pa	24	20	44	0	0	0
Conowingo, Md	10	15	25	0	0	0
Tennessee River:						
Chattanooga, Tenn	16	54	70	0	0	0
Bridgeport, Ala	2	27	29	0	1	1
Pickwick Landing, Tenn	2	36	38	0	0	0
Lenoir City, Tenn	9	24	33	<1	0	<1
Tombigbee River: Columbus, Miss	12	15	27	0	<1	<1
Truckee River: Farad, Calif	5	11	16	—	—	—
Verdigris River: Nowata, Okla	10	47	57	<1	2	2
Wabash River: New Harmony, Ind	93	37	130	5	1	6
Willamette River: Portland, Ore	39	15	54	<1	0	<1
Yakima River: Richland, Wash	3	25	28	0	1	1
Yellowstone River: Sidney, Mont	5	35	40	0	3	3

Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analysis are done weekly.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*7*). Because strontium-90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for November 1962. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult reference (*8*).

Quarterly strontium-90 results for the past year are shown in table 2. These data have been confirmed.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station.

REFERENCES

(*1*) Public Health Service: National Water Quality Control Network, *Fallout from Nuclear Weapons Tests*, *1*:167-9, Hearings before the Special Subcommittee on Radiation of the Committee on Atomic Energy, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1959), price $2.75.

(*2*) Division of Water Supply and Pollution Control, Public

TABLE 2.—QUARTERLY STATION AVERAGE CONCENTRATIONS OF STRONTIUM-90 IN RAW SURFACE WATERS, JULY 1961–JUNE 1962

[Concentrations in pc/liter]

Station	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Allegheny River: Pittsburgh, Pa	0.3	0.6	1.7	1.2
Animas River, Cedar Hill, N. Mex	0.3	0.9	0.8	1.0
Apalachicola River:				
Chattahoochie, Fla	0.4	0.5	*0.9	0.9
Arkansas River:				
Coolidge, Kans	2.3	1.0	0.6	3.9
Ponca City, Okla	—	0.6	1.3	3.0
Pendelton Ferry, Ark	—	0.5	1.3	—
Bighorn River: Hardin, Mont	—	—	*1.5	6.4
Big Sioux River:				
Sioux Falls, S. Dak	0.4	1.2	2.0	5.9
Chattahoochie River:				
Atlanta, Ga	—	0.3	0.5	0.8
Columbus, Ga	—	0.1	0.6	—
Chena Slough: Fairbanks, Alaksa	—	—	—	1.4
Clear Water River:				
Lewiston, Idaho	—	0.3	0.5	*0.4
Clinch River: Kingston, Tenn	—	—	—	1.7
Colorado River:				
Loma, Colo	—	0.8	1.2	1.5
Page, Ariz	—	1.9	1.5	4.9
Boulder City, Nev	1.0	1.8	1.3	2.0
Parker Dam, Calif-Ariz	—	1.5	1.0	1.7
Yuma, Ariz	—	0.7	0.6	1.0
Columbia River:				
Northport, Wash	—	—	—	0.6
Wenatchee, Wash	—	0.7	0.9	0.8
Pasca, Wash	1.1	0.7	1.1	0.8
McNary Dam, Ore	1.2	0.6	0.9	0.7
Bonneville Dam, Ore	*0.6	0.8	1.1	1.6
Clatskanie, Ore	—	0.6	0.7	0.7
Connecticut River:				
Wilder, Vt	—	3.7	0.8	0.8
Northfield, Mass	0.4	0.4	0.6	1.0
Cumberland River:				
Clarksville, Tenn	0.4	0.9	—	—
Delaware River:				
Martins Creek, Pa	—	0.5	0.7	1.1
Trenton, N. J	—	0.7	1.0	1.6
Philadelphia, Pa	—	—	*0.7	1.3
Escambia River, Century, Fla	*0.9	0.5	0.4	1.1
Great Lakes:				
Duluth, Minn	—	0.1	0.8	0.5
Sault Ste. Marie, Mich	—	0.5	0.5	0.6
Milwaukee, Wis	—	0.8	0.5	0.7
Gary, Ind	0.2	0.1	0.9	0.7
Port Huron, Mich	0.4	0.8	0.8	1.3
Detroit, Mich	*0.6	0.4	1.1	1.2
Buffalo, N. Y	—	0.8	1.0	1.1
Hudson River: Poughkeepsie, N. Y	0.2	2.5	1.1	1.7
Illinois River:				
Peoria, Ill	0.4	0.7	1.0	1.7
Grafton, Ill	—	0.6	2.5	2.4
Kanawha River:				
Winfield Dam, W. Va	—	0.5	0.4	0.8
Klamath River: Keno, Ore	—	1.2	1.1	1.3
Little Miami River:				
Cincinnati, Ohio	1.1	0.6	1.3	2.9
Merrimack River: Lowell, Mass	*0.7	—	—	—
Mississippi River:				
St. Paul, Minn	0.9	0.6	1.3	3.9
Dubuque, Iowa	—	0.8	0.7	2.9
Burlington, Iowa	0.6	1.9	1.0	2.0
E. St. Louis, Ill	—	0.9	1.2	2.2
Cape Girardeau, Mo	0.8	1.0	1.4	2.8
W. Memphis, Ark	—	1.1	1.5	2.7
Delta, La	*0.4	1.8	1.0	1.9
New Orleans, La	—	0.7	1.4	2.3
Vicksburg, Miss	—	0.7	2.0	3.1
Missouri River:				
Williston, N. Dak	—	1.2	1.4	1.1
Bismarck, N. Dak	—	1.1	1.4	1.9
Yankton, S. Dak	0.6	2.5	0.7	2.3
Omaha, Nebr	—	0.7	1.0	4.2
St. Joseph, Mo	—	0.5	1.1	3.0
Kansas City, Kans	—	0.9	0.5	1.8
Missouri City, Mo	—	—	1.5	2.8
St. Louis, Mo	1.4	2.1	1.3	2.7
Monongahela River:				
Pittsburgh, Pa	0.4	1.3	0.7	0.9
North Platte River: Henry, Nebr	—	1.3	0.5	2.2
Ohio River:				
E. Liverpool, Ohio	0.4	—	1.2	1.5
Huntington, W. Va	—	1.0	0.6	1.9
Cincinnati, Ohio	—	0.6	1.2	1.9
Louisville, Ky	0.4	0.7	1.3	1.3
Evansville, Ind	—	0.9	1.0	1.4
Cairo, Ill	1.1	—	1.4	2.0
Ouachita River: Bastrop, La	—	0.7	2.0	1.6
Pend Oreille River:				
Albeni Falls Dam, Idaho	—	—	—	1.6
Platte River: Plattsmouth, Nebr	—	0.4	2.2	6.0
Potomac River:				
Williamsport, Md	—	0.9	0.5	0.9
Great Falls, Md	—	0.6	1.1	2.2
Rainy River:				
International Fls., Minn	—	0.3	2.4	1.4
Baudette, Minn	—	—	1.4	2.4
Red River, North:				
Grand Forks, N. Dak	—	1.1	—	—
Red River, South:				
Denison, Tex	—	2.2	2.2	2.2
Index, Ark	—	1.7	2.1	6.1
Alexandria	1.0	2.7	1.1	2.5
Rio Grande River:				
Alamosa, Colo	*0.4	—	*0.6	1.1
El Paso, Tex	—	—	*0.5	1.2
Laredo, Tex	—	0.6	0.4	2.0
Brownsville, Tex	—	0.6	0.9	1.2
Roanoke River:				
John H. Kerr Resr. & Dam, Va	—	0.6	0.6	2.5
Sabine River: Ruliff, Tex	—	0.7	1.3	1.7
Sacramento River: Greens Landing, Courtland, Calif	—	—	—	0.9
San Juan River:				
Shiprock, N. Mex	—	1.3	1.9	1.0
St. Lawrence River:				
Massena, N. Y	—	1.6	0.8	1.2
Savanah River:				
North Augusta, S. C	—	—	0.8	1.0
Port Wentworth, Ga	0.4	0.6	0.9	1.9
Schuylkill River: Philadelphia, Pa	—	—	*0.6	1.5
Shenandoah River: Berryville, Va	—	0.2	0.4	0.9
Ship Creek: Anchorage, Alaska	—	—	—	*0.2
Snake River:				
Wawawai, Wash	0.3	0.2	0.9	0.6
Ice Harbor Dam, Wash	—	—	—	0.9
Payette, Idaho	—	2.5	0.3	0.6
South Platte River:				
Julesburg, Colo	.07	1.2	0.8	1.7
Spokane River: Post Falls, Idaho	—	—	—	0.7
Susquehanna River:				
Sayre, Pa	0.3	0.2	0.9	1.2
Conowingo, Md	0.3	0.9	0.5	1.0
Tennessee River:				
Chattanooga, Tenn	0.6	0.5	0.6	1.6
Bridgeport, Ala	0.7	1.5	2.0	2.0
Pickwick Landing, Tenn	—	0.4	1.3	1.7
Lenoir City, Tenn	—	—	1.2	1.1
Tombigbee River: Columbus, Miss	—	0.2	0.9	1.4
Truckee River: Farad, Calif	—	0.1	0.8	0.9
Verdigris River: Nowata, Okla	—	—	—	3.1
Wabash River: New Harmony, Ind	—	—	1.3	4.7
Yakima River: Richland, Wash	0.4	0.7	0.6	0.4
Yellowstone River: Sidney, Mont	—	1.2	1.3	30

* Six months composite—added period required to obtain sufficient sample for analysis.

Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1960 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

(*3*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data*, *1*:20-31 (October 1960).

(*4*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association*, *53*:704 (June 1961).

(*5*) Setter, L. R., J. E. Regnier, and E. A. Diephaus: Radioactivity of Surface Waters in the United States, *Journal of the American Water Works Association*, *51*:1377 (November 1959).

(*6*) Robert A. Taft Sanitary Engineering Center, Public Health Service: *Radionuclide Analysis of Environmental Samples*, Technical Report, R59-6 (1959).

(*7*) Straub, C. P., L. R. Setter, A Goldin and P. F. Hallbach: Strontium-90 in Surface Waters in the U.S., *Journal of the American Water Works Association*, *52*:756 (June 1960).

(*8*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1962-1963 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (To be published).

NORTH CAROLINA SURFACE WATER[1]
June 1958–December 1961

Sanitary Engineering Division
North Carolina State Board of Health[2]

The greater use of radioactive materials within the State of North Carolina presents an ever increasing concern to the State Board of Health and water works officials responsible for water quality. In view of this mounting problem, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health began in June 1958, with the cooperation of municipalities, a program of measurement of radiation background within the surface waters used as sources of public water supplies. Some 147 sampling points were established to sample raw surface water.

Background Radioactivity in Water

All waters contain traces of radioactivity which originate from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these minerals are trace elements of potassium-40, radium, thorium, and uranium. Such trace elements are dissolved by water as it finds its way to the watercourses, or as it flows within the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases such as thoron and radon, are removed from the atmosphere.

The combination of these radioactive materials imparts radioactive characteristics to the water and constitutes what is known as "background radioactivity" of the water.

A knowledge of the concentration of this background radioactivity is an important factor in the present and future appraisal of water quality for several reasons. First, once the background radioactivity has been changed due to the addition of isotopes, fission products, or other types of radioactive material, it may not be possible to establish what the original background may have been. Second, standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background" (*2*). Third, the knowledge of background radioactivity is the future yardstick by which the extent of pollution of added radioactivity and the control of such material on the watershed areas can be determined. The present program was established to determine this baseline information.

Table 3 gives the average background radioactivity as well as the maximum and minimum values recorded over the period June 1958 through October 1961. The first column consists of code numbers which indicate the geographical positions of the sampling stations shown in figure 1.

Laboratory Procedure

Total solids content is determined for each

[1] Abstracted from reference (*1*)
[2] Raleigh, North Carolina

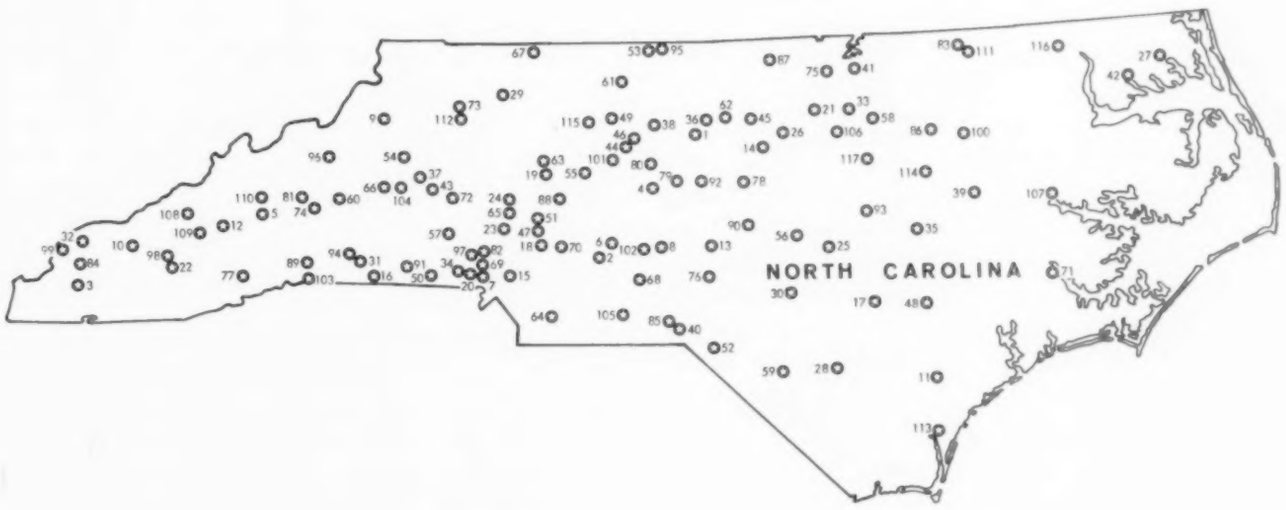

FIGURE 2.—NORTH CAROLINA SURFACE WATER SAMPLING STATIONS WITH CODE NUMBERS, 1958-1961

TABLE 3.—AVERAGE BACKGROUND RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, JUNE 1958–OCTOBER 1961

Code number	Location	Source of water supply	Number of samples surveyed	Background activity in μμc/liter[b]		
				Average	Maximum[a]	Minimum
1	Alamance	Big Alamance Creek	16	7.04	9.77	3.87
2	Albemarle	Yadkin River	29	5.11	17.39	1.95
3	Andrews	Beaver Creek	16	2.58	6.11	1.14
4	Asheboro	Back Creek	15	7.94	32.62	2.31
5	Asheville	Bee Tree Creek	35	2.17	8.19	0.84
6	Badin	Yadkin River	16	6.50	14.11	2.39
7	Belmont	Catawba River	15	6.14	23.77	1.52
8	Biscoe	Little River	14	6.34	7.72	3.2
9	Blowing Rock	Brickhouse Creek	33	4.92	14.69	1.00
10	Bryson City	Lands Creek	17	1.89	5.90	1.00
11	Burgaw	NE Cape Fear River	18	9.18	29.51	2.18
12	Canton	Pigeon River; Ruff Creek	15	1.63	3.51	1.09
13	Carthage	Spring	16	4.18	9.87	1.68
14	Chapel Hill	Price Creek	16	5.39	15.9	1.69
15	Charlotte	Catawba River	33	4.61	18.08	1.36
16	Cliffside	Second Broad River	33	8.70	36.12	1.84
17	Clinton	Black River	29	5.77	31.12	1.69
18	Concord	Cold Water Creek & Lumby Creek	34	10.63	38.05	3.00
19	Cooleemee	South Fork Yadkin	16	7.66	16.70	1.20
20	Cramerton	South Fork Catawba River	16	8.46	21.20	1.77
21	Creedmoor	Ledge Creek	16	10.60	17.8	2.56
22	Cullowhee	Long Branch; Flat Creek	15	2.37	4.86	1.25
23	Davidson	Cathy's Creek	14	4.80	6.9	2.92
24	Denton	Lick Branch	15	13.04	31.66	2.64
25	Dunn	Cape Fear River	11	15.97	49.90	5.21
26	Durham	Flat River	32	9.71	25.97	2.83
27	Elizabeth City	Pasquotank River	16	15.96	23.6	10.30
28	Elizabethtown	Cape Fear River	21	6.84	24.52	2.16
29	Elkin	Big Elkin Creek	17	3.98	12.15	1.11
30	Fayetteville	Cape Fear River	30	6.94	39.84	1 37
31	Forest City	Second Broad River	16	7.26	34.20	2.02
32	Fontana Dam	Little Tennessee River	16	2.94	9.3	1.04
33	Franklinton	Kearney's Creek	17	5.90	14.21	1.98
34	Gastonia	Long Creek; Catawba River	33	5.74	28.38	1.75
35	Goldsboro	Little River; Neuse River	20	10.25	27.02	1.83
36	Graham	Back Creek	16	8.56	12.70	4.32
37	Granite Falls	Catawba River	15	3.95	11.22	1.13
38	Greensboro	Reedy Fork Creek	34	8.59	30.60	2.07
39	Greenville	Tar River	31	8.58	29.66	2.27
40	Hamlet	Marks Creek	15	7.54	28.76	1.34
41	Henderson	Sandy Creek	10	5.91	18.69	2.49
42	Hertford	Perquimans River	16	15.30	26.10	5.21
43	Hickory	Catawba River	30	4.41	12.25	1.04
44	High Point	Deep River	27	11.52	35.26	2.69
45	Hillsboro	Eno River	17	6.84	21.4	2.65
46	Jamestown	Deep River	13	15.39	26.86	1.31
47	Kannapolis	Buffalo Creek	33	7.07	29.72	1.35
48	Kenansville	NE Cape Fear River	11	11.94	47.00	1.72
49	Kernersville	Belew's Creek	14	6.81	19.15	2.38
50	Kings Mountain	Kings Creek	16	2.35	19.63	1.77
51	Landis	Grant's Creek	16	7.25	33.35	2.02
52	Laurinburg	Jordan Creek	17	4.30	17.20	0.99
53	Leaksville	Dan River	32	9.64	63.10	2.46
54	Lenoir	Zacks Fork Creek & Catawba River	15	5.62	12.36	1.48
55	Lexington	Abbott's Creek	16	8.96	20.56	2.69
56	Lillington	Cape Fear River	16	10.79	30.4	4.78
57	Lincolnton	Walker Branch	16	4.89	4.25	1.53
58	Louisburg	Tar River	14	6.28	23.39	2.48
59	Lumberton	Lumber River	32	6.16	17.12	1.52
60	Marion	Mackey's Creek; Buck Creek	18	1.34	2.03	0.87
61	Mayodan	Mayo River	17	7.81	37.70	1.60
62	Mebane	Mills Creek	15	4.48	7.20	1.69
63	Mocksville	Bear Creek	17	15.06	81.00	2.61
64	Monroe	Richardson Creek	17	13.19	52.05	2.58
65	Mooresville	Byers Creek; Catawba River	19	8.44	43.33	2.30
66	Morganton	Henry River	17	1.82	3.70	1.05
67	Mount Airy	Lovell's Creek	17	2.38	5.90	1.01
68	Mount Gilead	Pee Dee River	16	7.48	41.13	2.05
69	Mount Holly	Catawba River	16	4.15	13.93	1.43
70	Mount Pleasant	Dutch Buffalo Creek	14	9.19	20.57	3.27
71	New Bern	Neuse River	22	5.07	10.34	1.59
72	Newton	Jacobs Fork	11	9.01	28.49	1.39
73	North Wilkesboro	Reddies River	31	6.03	52.72	1.18
74	Old Fort	Jarrett Creek	16	2.04	5.23	1.13
75	Oxford	Tar River; Hatcher's Run	16	9.30	43.88	2.22
76	Pinehurst	Rattlesnake Branch; Juniper Branch	15	3.59	12.85	1.34
77	Pisgah Forest	Davidson River	15	3.59	12.85	0.89
78	Pittsboro	Robinson Creek	17	8.98	35.89	3.35
79	Ramseur	Sandy Creek	17	6.28	14.51	2.21
80	Randleman	Pole Cat Creek	16	15.95	69.31	3.30
81	Ridgecrest	Mountain Stream	17	1.55	2.99	0.89
82	Riverbend	Catawba River	17	4.72	18.34	1.36
83	Roanoke Rapids	Roanoke River	32	6.14	16.54	1.64
84	Robbinsville	Rock & Burgin's Creek	17	2.06	6.37	0.94

TABLE 3.—AVERAGE BACKGROUND RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, JUNE 1958–OCTOBER 1961—Continued

Code number	Location	Source of water supply	Number of samples surveyed	Background activity in μμc/liter		
				Average	Maximum[a]	Minimum[b]
85	Rockingham	Falling Creek	11	6.27	18.42	1.37
86	Rocky Mount	Tar River	15	13.17	57.10	3.31
87	Roxboro	Lake Isaac Walton; Storey's Creek	17	10.55	35.74	2.98
88	Salisbury	Yadkin River	14	12.31	60.20	2.57
89	Saluda	Paces Creek	17	1.80	3.50	1.06
90	Sanford	Lick Creek; Potterage Creek	17	8.67	47.35	1.72
91	Shelby	First Broad River	30	3.27	32.92	1.12
92	Siler City	Rocky River	16	9.56	34.36	2.51
93	Smithfield	Neuse River	29	13.17	28.46	4.00
94	Spindale-Rutherfordton	Hollands Creek; Cathy's Creek	17	3.35	11.55	1.90
95	Spray	Smith River	34	7.66	61.80	2.00
96	Spruce Pine	Beaver Creek	16	2.00	4.23	1.21
97	Stanley	Hoyle's Creek	17	6.36	31.13	2.07
98	Sylva	Dill's Creek	31	3.31	17.01	0.84
99	Tapoco	Yellow Hammer Creek	17	1.78	3.77	0.94
100	Tarboro	Tar River	17	8.34	32.46	1.30
101	Thomasville	Abbott's Creek	17	10.79	59.02	3.80
102	Troy	Denson Creek; Downing Creek	17	5.83	15.82	1.57
103	Tryon	Falls Creek; Vaughn's Creek	17	3.30	4.08	1.32
104	Valdese	Micol Creek; Hoyle Creek; Catawba River	17	5.86	18.40	1.83
105	Wadesboro	Jones Creek	17	7.66	33.29	1.85
106	Wake Forest	Smith's Creek	17	4.28	8.25	1.39
107	Washington	Tranters Creek	17	8.65	36.42	2.31
108	Waterville	Big Creek	17	1.55	3.03	0.94
109	Waynesville	Cherry Cove & Shiney Creek	17	2.59	9.14	1.16
110	Weaverville	Wagner Branch & Ox Creek	17	1.76	3.47	0.82
111	Wedlon	Roanoke River	17	5.30	16.11	2.69
112	Wilkesboro	Cub Creek	16	3.16	7.38	1.11
113	Wilmington	Cape Fear River	32	11.20	86.00	2.16
114	Wilson	Contentney Creek	33	3.90	28.87	2.07
115	Winston-Salem	Salem Creek	33	6.64	20.12	1.64
115	Winston-Salem	Yadkin River	33	7.31	26.04	1.24
116	Winton	Chowan River	29	7.77	25.46	1.79
117	Zebulon	Little River	16	4.62	10.60	1.64

[a] Maximum values have 95 percent accuracy ± 20 percent.
[b] Minimum values have 95 percent accuracy ± 60 percent.

sample so that proper sample proportions may be used in analysis. The calculated amount of a sample, based on solids content, is concentrated to a few milliliters on a steam bath. The residue is transfered to a stainless steel planchet and evaporated to dryness under an infrared light. After further drying for one hour at 103°C., the sample is cooled in a dessicator and is then counted.

Alpha plus beta counting is done in a gas-flow internal proportional counter which is calibrated with a radium-D E source. On the vasis of instrument background, each sample is counted for a preset count and the results are reported in terms of micromicrocuries per liter.

Interpretation of Results

The measurement of radioactivity at low levels or low concentrations is difficult because of the many variable factors such as types and energy of radiation, necessary concentration to obtain a representative sample, and efficiency of counting which includes absorption, scatter, and geometry.

All results may be interpreted on the basis of the maximum permissible continuous occupational concentration or radioactivity concentration guide set forth by the Subcommittee on Permissible Internal Dose of the National Committee on Radiation Protection. This has been established at 100 micromicrocuries per liter of water for the total activity of unknown isotopes (*3*). This value relates to average intake from water over a long period of time and not from transient conditions.

Individual sample data and associated errors are contained in reference (*1*). Only significant values were used in calculating the arithmetic averages given in this report. The significant increase in activity recorded for the period from November 9, 1961 to December 31, 1961 is probably due to the presence of fission material produced during the renewed atmospheric testing of nuclear weapons. For this reason, the values recorded during this period were not included in the calculations of the average background radioactivity.

From a study of the results, it can be noted that the mountain waters contain less radioactivity than those in the Piedmont and further east (see figure 1 and table 3). This is to be expected since the waters in the mountains contain less mineral

content. As both surface and subsurface waters flow toward the ocean their dissolved solids content, paralleled by their concentrations of natural radioactivity, increases. Hence, from results to date, it cannot be assumed that the minerals in the Piedmont in the eastern part of the State necessarily contain more radioactivity than those in the western part.

Previous coverage in *Radiological Health Data:*

Period	Issue
June-August 1962 (cistern water)	*February 1962*

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(*1*) North Carolina State Board of Health Sanitary Engineering Division and State Laboratory of Hygiene: *Background Radioactivity in Surface Water Supplies of North Carolina 1958-1961.*

(*2*) International Commission on Radiological Protection: *Recommendations of the International Commission on Radiological Protection (Adopted September 9, 1958)*, Pergamon Press, New York (1959).

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SECTION IV.—OTHER DATA

Control of Luminous Dial Watches in New York City

Ira R. Paul[1]

Introduction

The Office of Radiation Control of the New York City Department of Health was created for the purpose of administering a control program to protect the general public, as well as workers in certain installations, from the dangers inherent in the uncontrolled use of radioactive materials or ionizing radiation. Most of its efforts concern the use of X rays and radioactive materials, including radium, in medical installations, schools and institutions, but occasionally it is necessary to deal with other radiation problems. One of these, the use of radioactive materials in watches, is of particular interest because of the widespread use and popularity with young people of luminous-dial watches.

New York City's efforts to limit the public exposure from radium-dial timepieces began on March 19, 1958, with the enactment of Article 175 of the New York City Health Code which prohibited the "storage, manufacture, repair, handling, or use of any timepieces, instruments, novelties or devices, if done in such a manner that any person is exposed to radiation dose rates in excess of limitations recommended by the National Committee on Radiation Protection and Measurements (*1*)."

Upon the recommendation of the Mayor's Technical Advisory Committee on Radiation, these dose rates were interpreted to limit the radiation emission through the front surface of pocket watches to no more than 0.1 mrad per hour and the radiation emission through the back surface of wrist watches to no more than 1.0 mrad per hour.

It was estimated, by general observation, that pocket watches are worn for an average of 100 hours per week, 50 weeks per year, facing the body in a pocket near the belt-line. Wrist watches may be worn with the back surface in contact with the skin of the forearm for approximately 150 hours per week, and thus it was necessary to establish separate criteria for each of these two styles of watches.

The National Committee on Radiation Protection and Measurements (NCRP) (*2*) has recommended that the maximum permissible dose (MPD) to the head, trunk, active blood-forming organs, gonads or lens of the eye of radiation workers shall not exceed 5 rems per year, and the maximum permissible dose to the hand or forearms shall not exceed 75 rems per year. The NCRP has further advocated the principle that the general population should not receive radiation at a weekly rate higher than one-tenth the respective permissible weekly dose for the critical organs and other body tissues.

The Federal Radiation Council's Radiation Protection Guides (RPG) (*3*) also recommended the above values not be exceeded for radiation workers. When considering individual members of

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the population, a whole body dose of 0.5 rem per year should not be exceeded. Similarly, with an average mumber of the population, a 30-year gonadal dose of 5 rem should not be exceeded. As an operational technique, where the individual whole body doses are not known, a suitable sample of the exposed population should be developed whose protection guide for annual whole body dose will be 0.17 rem per capita per year. The FRC has not recommended specific guides for exposure of the hands and forearms.

Using the NCRP dose rates as a guide for control at the radiation source rather than at the organ of interest, it then follows that if a pocket watch is worn for 5,000 hours per year, and the MPD is 0.5 rems (500 mrems), then the emission rate at the surface of the crystal should be a maximum of 0.1 mrad per hour. If a wrist watch is used for 7,500 hours per year, and the MPD is 7.5 rems (7,500 mrems), then the emission rate at the surface of the back should be a maximum of 1.0 mrad per hour.

Numerous wrist watches were tested and, with the exception of some skin-divers watches, were found to fall within the established limits.

Literature Survey

Joyet (*4*) reported in 1958 that the average man's luminous wrist watch contains 0.36 microcuries of radium and the average woman's wrist watch contains 0.13 microcuries. He calculated that a man wearing such a watch 24 hours a day receives a gondal dose of 21.8 mr per year and a woman receives a gondal dose of 12.7 mr per year.

Using Joyet's results, a sampling by the New York AEC operations office of 224 persons (including those not wearing watches and those wearing watches with non-luminous dials) in New York City indicated an average gonadal exposure of 3 mr per year per person to age 35. The 35-year dose is then about 0.1 r, which amounts to approximately 3 percent of natural background radiation and only about 1.5 percent of the total radiation dose derived from background plus medical and dental exposure to the gonads, as currently estimated (*5*).

Eng, LeCoultre and Lerch (*6*) examined 684 wrist watches produced in Switzerland in 1961, and found the highest percentage of these watches contained approximately 0.1 microcuries of radium-226 and emitted less than 1 mrem per hour through the back. Quite evidently, the trend has been to reduce the amount of radium on watches.

Seelentag and Schmier (*7*) state that most German-made watches have radium amounting to less than 0.06 microcuries and usually only about 0.02 microcuries. The radiation exposure to wearers of such watches amounts to a small percentage (about 1 percent) of natural background radiation exposure, and the local exposure to the skin of the forearm amounts to only a few percent of the maximum permissible occupational dose.

Although no comparable study has been made with radium-dial pocket watches, the fact that they are worn in relatively close proximity to the gonads, roughly 28 cm for the average male, makes the pocket watch potentially a much greater genetic hazard than a wrist watch with equal amounts of radium-226. In considering the dose to the abdomen, the fact that the radium emanations are shielded only by the thin glass crystal and a few mg/cm^2 of cloth, rather than the mechanism and back of the wrist watch, again makes the pocket watch a potentially greater hazard to the wearer.

Survey Results and Laboratory Calibration Procedures

In 1960, a large department store and a large cutlery chain, both in New York City, advertised radium-dial pocket alarm watches. Samples of these watches were obtained and tested, and were found to emit 4 mrads per hour at their faces. The stores were notified, and they voluntarily removed these watches from sale.

In 1962, the manager of a mail order company, after being informed that the radiation emission from the pocket watches he had advertised was excessive, complained that there were many other sales outlets for these watches throughout the city. An inspection team was sent out and took a random sampling of 77 jewelry, department, novelty, and cigar stores. About half of these stores were found to be stocking radium dial pocket watches.

Rough field measurements, made with a portable end-window G-M survey meter having scale ranges of 0–30 and 0–100 mr/hr and a window thickness of 1.5 to 2.0 mg/cm^2, gave readings of from 3 to 10 mr/hr for various makes and models, with the window of the probe in contact with the surface of the watch crystal.

Admittedly, this procedure was crude, but since

all readings were on the low side due to poor geometry, it established the fact that all of the pocket watches checked exceeded the acceptable limits. Calibration of the instrument was obtained utilizing a 10.08 mg radium needle encapsulated in 0.5 mm of platinum, and using a factor of 0.825 to convert the mg of radium to mr per hour at a meter.

Two pocket alarm watches were placed in the whole body counter at the Atomic Energy Commission's New York Operations Office. Watch "A" was estimated to contain 0.15 microgram of radium, and watch "B" 0.015 microgram of radium. When checked with the G-M counter, the dose reading at the surface of the crystal of watch "A" was 8 mrad per hour and that of watch "B" was 1.2 mrad per hour.

To check depth of penetration in tissue, a pocket watch "C" which gave a reading of 8 mrad per hour on the G-M meter, and another pocket watch "D" which gave a reading of 3 mrad per hour, were used as radiation sources with an approximately tissue-equivalent pressed-wood phantom. Watch "C" had a gamma component that penetrated 8.25 inches of the phantom before reaching background levels and the gamma component of watch "D" penetrated 2.44 inches.

Again it is emphasized that the G-M meter is used only for fast field determinations. A more precise method, used in the laboratory, utilizes films. Exposure dose rates obtained by the film method are about three times higher than those obtained for the same watch by the G-M meter method.

Because a fast film is desirable, it was found convenient to use the same personnel dosimeter packet, Dupont type 556, that is used to monitor our laboratory and field personnel. This is a double film packet with a sensitive component, type 508, and an insensitive component, type 834. Only the sensitive film, the 508, which is at the front of the packet, is utilized for watch dosimetry.

Autoradiographs are obtained by taping two packets, side by side, on the face of the pocket watch, with the front of the packet in contact with the crystal. The films are left in place for two to three days. The time necessary to produce a satisfactory autoradiograph was previously determined by G-M counter measurement. During this time, the watch is kept wound, to simulate actual wearing conditions. In this way, the radium on the moving hands will distribute its energy over the area of the face, rather than concentrate it in one spot. Numbers or spots on the dial that are coated with radium are naturally stationary, and the film will receive greater exposure at these points. This is not too distinct, however, since a great deal of scattering takes place within the glass crystal, resulting in a blurred image. Figure 1 shows an example of an autoradiograph produced using this procedure. An autoradiograph made with the hands stationary is also shown (figure 2) to demonstrate that improper technique (watch not wound) would give false readings.

The films are developed along with unexposed films from the same emulsion batch. The purpose of these unexposed films is to establish a base and fog limit. After thorough drying, the net density of the films is determined with a densitometer. The "net density" is the density above base density and fog. Thus, net density is the density produced by the exposure (*8*).

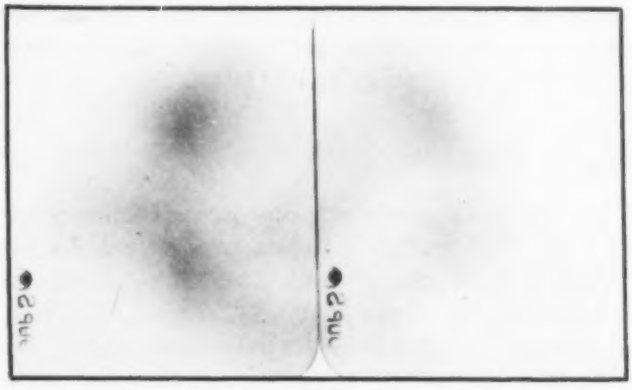

FIGURE 1.—ENLARGED PRINT OF AUTORADIOGRAPH FOR WATCH WOUND DURING EXPOSURE TIME

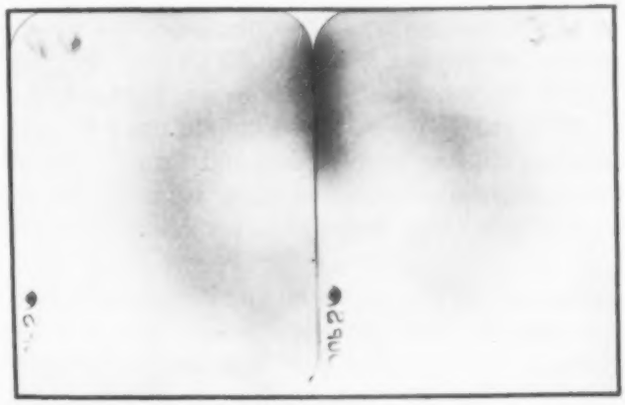

FIGURE 2.—ENLARGEMENT PRINT OF AUTORADIOGRAPH FOR WATCH UNWOUND DURING EXPOSURE TIME

The results are then compared against a radium-226 calibration curve (see figure 3). To establish this curve, the same radium source is used that is used to calibrate the G-M counter. Dupont type 556 film packets are placed a distance of one meter from the source, and removed individually at varying time intrvals. The exposure received by each film is checked with a Victoreen Condenser R-Meter thimble chamber. After development and determination of the net density of each film the net densities are plotted against exposure in milliroentgens on semilogarithmic paper, and a characteristic curve is obtained (*9*). Because the steepest slope occurs between net densities of 0.3 and 1.0, the exposure time of the watch film is estimated to bring the exposure into this curve segment.

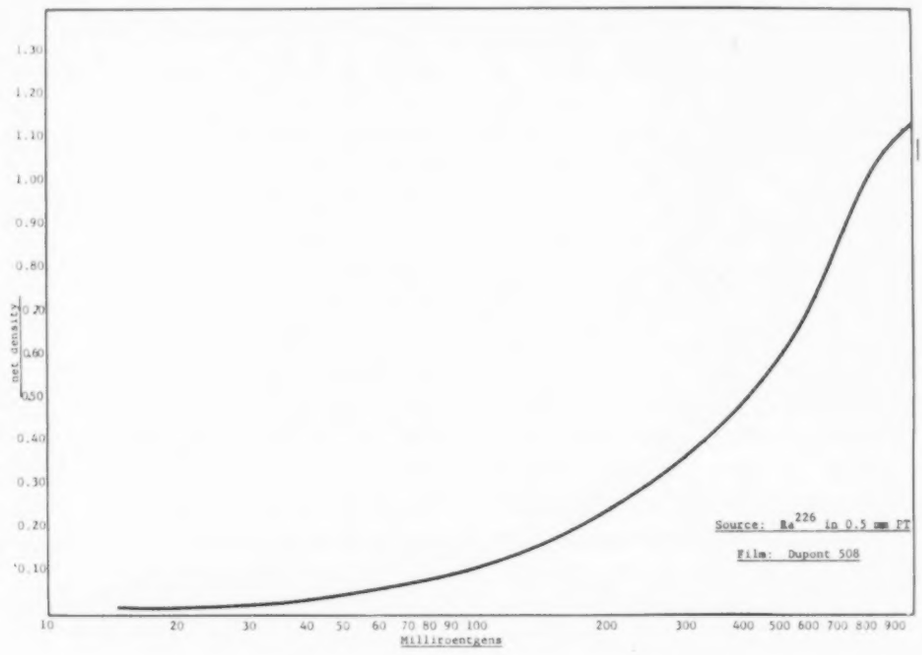

FIGURE 3.—RADIUM-226 CALIBRATION CURVE

This is, of course, a gamma curve to which a beta-gamma exposure is being related. The beta component of the watch-dial radium which penetrates the glass crystal, the white and green protective film papers (weight = 27.4 mg/cm²) and the film emulsion itself is in the energy range above 0.5 Mev (10). The response of photographic film has been studied by Fleeman and Frantz (*11*) for beta radiation energies ranging from 0.5 to 1.4 Mev. Within these limits, film response was found to be proportional to the dose received and independent of the energy of the incident electrons.

Most of the beta particles are filtered out before reaching the emulsion, but radium E (bismuth-210) has a 1.17 Mev beta which has a range of 500 mg/cm² (*10*). The beta-ray sensitivity of the film is almost proportional to the gamma-ray sensitivity, and therefore the film densities are based upon a 1-to-1 beta-gamma ratio (*12, 13*).

Using this method, gamma skin dose rates as high as 20 mrads per hour, or 200 times the authorized emission rates, were recorded. These values indicated some action had to be taken.

Regulatory Action.

A notice to manufacturers and distributors of radium dial pocket watches was issued by the Office of Radiation Control, which set forth the interpretations of the Mayor's Technical Advisory Committee on Radiation as previously stated. The notice requested that the offer for sale or supply of radium-dial pocket watches to retail stores within New York City be discontinued at once, and that

all existing stocks on consignment from retail outlets be withdrawn by February 1, 1963.

Following this, New York City Board of Health enacted the following amendment to the "Radiological Hazards" section of the Health Code, to become effective on February 1, 1963:

"A permit shall be required for any timepiece, instrument, novelty or device containing radioactive material other than hydrogen-3 (tritium), if the regular use thereof in the usual manner will expose the user to a radiation dose in excess of 0.5 rems per year to the head, trunk, active blood-forming organs, gonads, or lens of the eye, or will expose the hands or forearms to a dose in excess of 7.5 rems per year, when used regularly."

The new amendment does not necessarily mean that watches having excessive quantities of radium are absolutely prohibited from sale. Such a watch may be sold to anyone having a Health Department permit to possess one. This is to allow anyone who might have a legitimate professional need for such a watch to use one under the necessary safeguards prescribed in the terms of a license.

Summary

The New York City Department of Health has enacted an amendment to the Health Code, affecting timepieces containing radioactive material other than tritium, which considers the recommendations of the NCRP and the FRC. This has been interpreted by the Mayor's Technical Advisory Committee on Radiation to limit the radiation emission from the front of pocket watches to 0.1 mrad per hour, and from the back of wrist watches to 1.0 mrad per hour.

Rough field measurements of watches are made with an end-window G-M survey meter, but more precise measurements make use of autoradiographs on personnel dosimeter film.

Any person desiring the purchase a watch that emits radiation in excess of the specified limits may do so by demonstrating a legitimate, professional need and securing a permit from the New York City Department of Health.

Acknowledgment

I wish to express my appreciation to Hanson Blatz, Director of the Office of Radiation Control, for making available his files and correspondence, which aided immeasurably in the preparation of this paper.

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Enviromental Levels of Radioactivity of Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Argonne National Laboratory, Portsmouth Area Gaseous Diffusion Plant, and Shippingport Atomic Power Station.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in the National Bureau of Standards "Handbook 69" (NCRP report no. 22). The MPC values applicable to the reports that follow are given in table 1.

In these reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References to table 1 will be made to designate the appropriate MPC's adopted by the respective laboratories.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of radionuclides	Environmental MPC's	
		Water ($\mu\mu$c/liter)	Air ($\mu\mu$c/m^3)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present[a]	2,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[a]	—	100
8	Barium–lanthanum–140	20,000	4,000
9	Cerium–141	90,000	5,000
10	Cerium–144	10,000	300
11	Cesium–137	20,000	500
12	Cobalt–58	90,000	2,000
13	Cobalt–60	50,000	300
14	Hydrogen–3 (tritium)	3,000,000	500,000
15	Iodine–131	2,000	300
16	Plutonium–239	5,000	0.06
17	Ruthenium–103	80,000	20,000
18	Ruthenium–rhodium–106	10,000	200
19	Strontium–89	10,000	1,000
20	Strontium–90	100	10
21	Thorium–232	2,000	1
22	Thorium–protactinium–234	20,000	2,000
23	Uranium, natural	20,000	2
24	Xenon–133	—	300
25	Zirconium–niobium–95	60,000	1,000

[a] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or ess than $^1/_{10}$ and if the sum of these ratios for the group in question is equal to or less than $^1/_4$.

ARGONNE NATIONAL LABORATORY
1962

University of Chicago,
Lemont, Illinois
Air Monitoring

Weekly continuous air filter samples were collected at seven locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 off-site locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 2. The radionuclide determinations were made by gamma spectra of manthly composites of the filters. The data show little difference between off-site and on-site measurements for alpha activity and most of the nuclides, inferring that ANL does not contribute detectable quantities of these activities to the atmosphere.

Water Monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2 respectively.

On Sawmill Creek, weekly grab samples are collected upstream and three times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 3 show significantly higher concentrations downstream than upstream, an indication of the radioactivity contributed to the stream by ANL. A comparison of the downstream concentrations with the environmental MPC's listed in table 1 shows that all concentrations are relatively low.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL was not detected.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*April 1961*
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL 1962

[Concentrations in $\mu\mu c/m^3$]

Type of analysis	Sampling locations	1962 quarterly averages				1962 average
		1st quarter	2nd quarter	3rd quarter	4th quarter	
Alpha	on-site	0.0036	0.0054	0.0049	0.0055	0.0048
	off-site	0.0039	0.0052	0.0051	0.0060	0.0050
Beta	on-site	5.1	5.5	3.4	5.5	4.9
	off-site	4.9	5.1	3.3	5.7	4.8
$Ba-La^{140}$	on-site	[a] <0.01	0.032	0.60	1.5	0.56
	off-site	[a] <0.01	0.025	0.66	1.8	0.61
Ce^{141}	on-site	0.27	0.36	0.31	0.46	0.36
	off-site	0.23	0.39	0.29	0.45	0.34
Ce^{144}	on-site	0.85	1.6	1.0	1.5	1.3
	off-site	1.0	1.5	1.0	2.2	1.4
Cs^{137}	on-site	0.023	0.090	0.040	0.028	0.046
	off-site	0.034	0.065	0.042	0.030	0.043
Ru^{103}	on-site	0.38	0.23	0.21	0.44	0.32
	off-site	0.43	0.24	0.26	0.47	0.36
$Ru-Rh^{106}$	on-site	0.29	0.50	0.39	0.30	0.38
	off-site	0.30	0.51	0.37	0.30	0.38
$Zr-Nb^{95}$	on-site	1.9	1.6	0.86	1.3	1.4
	off-site	2.1	1.7	0.85	1.4	1.5

[a] Not analyzed during January and February.

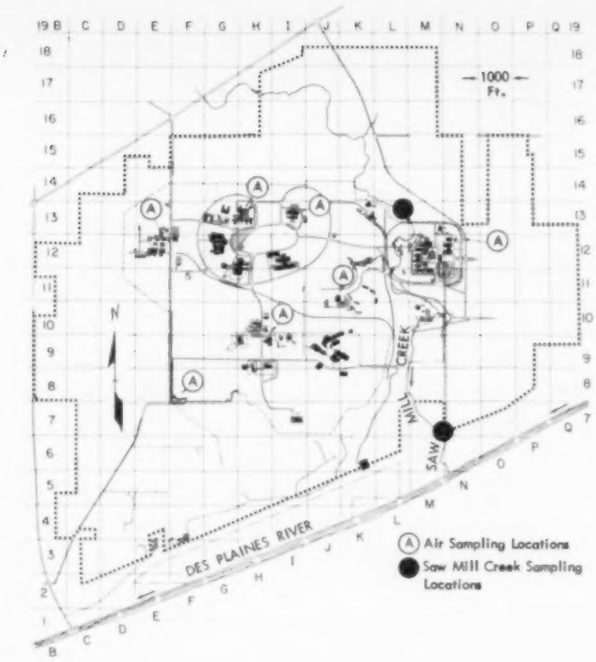

FIGURE 1.—ON-SITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

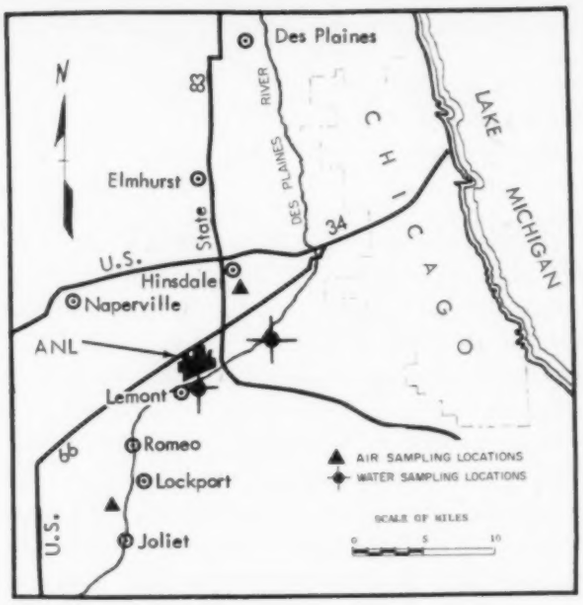

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFF-SITE SAMPLING STATIONS)

TABLE 3.—RADIOACTIVITY IN SAWMILL CREEK, ANL, 1962

Type of analysis	Sampling locations	Concentrations ($\mu\mu$c/liter)		
		Maximum	Minimum	1962 Average
Alpha emitters:				
Total alpha	upstream	4.1	0.2	1.6
	downstream	16.4	0.8	5.0
U-natural	upstream	1.9	0.4	1.0
	downstream	7.6	0.9	2.8
Pu^{239}	upstream	<0.05	<0.05	<0.05
	downstream	0.91	<0.05	0.12
Th^{232}	upstream	0.10	<0.05	<0.05
	downstream	0.48	<0.05	0.12
Beta emitters:				
Total beta	upstream	393	10	40
	downstream	806	17	66
Co^{58}	upstream	<5	<5	<5
	downstream	3,260	<5	136
Co^{60}	upstream	<3	<3	<3
	downstream	75	<3	6
Sr^{89}	upstream	56	<2	12
	downstream	25	<2	9.5
Sr^{90}	upstream	2.4	<0.5	1.2
	downstream	3.1	<0.5	1.2
I^{131}	upstream	<3	<3	<3
	downstream	11	<3	<3
Cs^{137}	upstream	7.7	<0.5	1.8
	downstream	254	<0.5	7.6
Ba^{140}	upstream	3.4	<1	<1
	downstream	1.8	<1	<1
Th-Pa^{234}	upstream	1.5	0.3	0.8
	downstream	6.1	0.7	2.2

PORTSMOUTH AREA GASEOUS DIFFUSION PLANT
1962

Goodyear Atomic Corporation
Portsmouth, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are collected monthly at 17 sites located from 1 to 6 miles from the plant as shown in figure 3. Monthly water samples are collected at 14 locations within 5 miles of the plant.

Average alpha and beta-gamma concentrations in air and water are summarized in table 4. The external gamma levels are measured at the air sampling locations shown in figure 3 and the results included in table 4.

Water alpha and beta-gamma concentrations remain essentially unchanged from previous quarters. The slight increase in external gamma dose rate is evidently a consequence of nuclear weapons testing fallout. Total amount of radiation detected was too small to determine the amount, if any, attributable to plant operations.

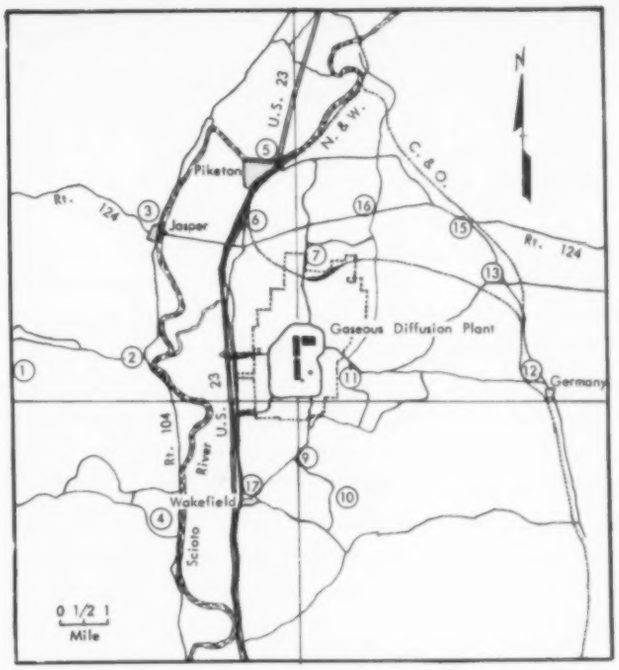

FIGURE 3.—AIR SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*November 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*

TABLE 4.—ENVIRONMENTAL RADIOACTIVITY, PORTSMOUTH PLANT, 1962

Basis of measurement	Number of samples	Unit	Maximum	Minimum	1962 average
Air (alpha concentration)	180	$\mu\mu c/m^3$	0.7	0.1	0.1
Air (beta-gamma concentration)	180	$\mu\mu c/m^3$	39.3	0.1	5.7
Water (alpha concentration)	162	$\mu\mu c$/liter	1,105	0.5	25.6
Water (beta-gamma concentration)	162	$\mu\mu c$/liter	1,030	14	61
External gamma	180	mrad/hr	0.076	0.015	0.038

SHIPPINGPORT ATOMIC POWER STATION
Second Half 1961 and First Half 1962

Duquesne Light Company,
Shippingport, Pennsylvania

Environmental radiation monitoring at the Shippingport Atomic Power Station began with a two-year preoperational survey program to establish background levels at the site of the world's first large-scale nuclear-powered electric generating station. Following initial operation of the plant in December 1957, this program was continued as orginally conceived through the third quarter of 1961, when it was determined that fewer sampling locations closer to the plant would provide equal or better evaluation of the effects of plant operation on the environment.

Area Monitoring

Reduced air monitoring is apparent from an examination of figure 4. Only two on-site monitoring trailers currently operate at the eastern and western boundaries, and one off-site unit operates at Midland. Air samples are collected continuously at each trailer and monitored for gross beta activity. Average concentrations of radioactivity in air for the last half of 1961 and the first half of 1962 are presented in table 5.

Beta-gamma radiation levels are also continuously monitored at these stations. There was no significant difference in average levels measured during the year under consideration from those of previous years. The average beta-gamma level for the last half of 1961 was 0.015 mrem/hr, and during the first half of 1962 the average beta-gamma level was 0.022 mrem/hr.

Until December 1961, fallout samples were collected weekly on gummed paper trays. No fallout samples were collected during December, but collections have been made monthly at the three monitoring stations since collection pots were placed in service on December 29, 1961. Fallout gross beta activity data for the year ending June 30, 1962 are summarized in table 6. Increased fallout levels during this time are attributed to fallout from weapons tests since there was no indication of any plant contribution.

Release of Radioactive Wastes to the Atmosphere

An incinerator for burning contaminated combustible material is located in the waste disposal plant. The exhaust from the incinerator passes through a wet gas scrubber and a filter before entering the stack.

During the third quarter of 1961, a total of 4,636 microcuries of gaseous radioactive waste (primarily xenon-133) was released to the atmosphere at a controlled rate over a period of 93 hours and 27 minutes. During the fourth quarter a total of 13,993 microcuries of gaseous radioactive waste (primarily xenon-133) was released to the atmosphere at a controlled rate over a period of 183 hours, the average concentration at the stack exit during release being 5,000 $\mu\mu c/m^3$. For 1961 as a whole, the release of these wastes totaled 103.5 millicuries, and the concentration at the stack exit during release average 8,100 $\mu\mu c/m^3$. There was no release of gaseous radioactivity to the atmosphere from the waste disposal system during the first half of 1962.

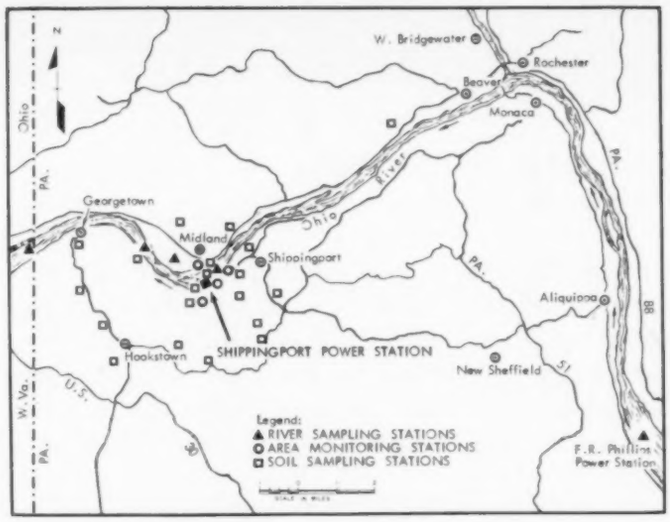

FIGURE 4.—SHIPPINGPORT POWER STATION SAMPLING LOCATIONS

TABLE 5.—AIRBORNE PARTICULATE RADIOACTIVITY, SHIPPINGPORT

[Average concentrations in $\mu\mu c/m^3$]

Values	Third quarter 1961	Fourth quarter 1961	Calendar year 1961	First half 1962
Minimum	0.08	0.08	0.06	0.08
Maximum	8.0	7.1	7.5	6.7
Average	1.5	1.5	1.2	0.89

Liquid Radioactive Waste Monitoring

Tritium (H^3) is released periodically in controlled quantities and concentrations to the Ohio River. Toward the end of 1960, the ion exchange resin in

TABLE 6.—GROSS BETA ACTIVITY IN FALLOUT, SHIPPINGPORT

[Average concentrations in mc/km²/month][a]

Sampling locations	Third quarter 1961	Fourth quarter 1961	Calendar year 1961	First half 1962
Upwind:				
½ mile SW of site	3.8	[b]RFS	1.9	[c]
½ mile NW of site	12.1	187	50.5	[c]
Downwind:				
On site SE of main bldg	9.0	6.3	525	[c]
½ mile NE of site	199	149	39.4	[c]
Average of all stations (except SW upwind)			47.4	[c]
Pot No. 1[d]	—	—	—	52.5
Pot No. 2	—	—	—	39.4
Pot No. 3	—	—	—	50.5

[a] One mc/km² = 2.59 mc/mi². [b] Removed from service. [c] Discontinued in 1962. [d] Collection of fallout in pots began December 29, 1961.

the reactor coolant purification system was changed from a natural lithium hydroxyl form to a lithium-7 enriched form. This change resulted in a decrease in tritium production within the reactor by a factor of about 30. The average total daily tritium activities released to the Ohio River during the last two quarters of 1961 were 7,000 and 4,000 respectively. The average tritium concentrations in the plant effluent channel during these periods were 53 μμc/liter and 37 μμc/liter, respectively. During the first half of 1962, the average total daily tritium activity released to the Ohio River was 3,900 μc and the average concentration in the plant effluent was 39 μμμc/liter.

Gross radioactivity of unidentified nuclides (does not include tritium) discharged during the last half of 1961 averaged 493 μc/day in the third quarter and 415 μc/day in the fourth quarter. Average concentrations in the effluent channel during release in these periods were 4.0 and 3.2 μμc/liter, respectively. During the first half of 1962, gross radioactivity of unidentified nuclides averaged 222 μc/day and totaled 40,323 microcuries. Monthly average concentrations in the effluent channel during releases in this period ranged from 1.5 to 4.2 μc/liter. These concentrations are in addition to normal background radioactivity in the condenser cooling water used for dilution in the effluent channel prior to discharge to the Ohio River.

The revised liquid radioactive waste sampling program became effective in the fourth quarter of 1961 and the first quarter of 1962 as follows: River water sampling was reduced by the end of the first quarter 1962 to weekly samples taken continuously at the plant intake and outfall to the Ohio River. These samples are analyzed for gross alpha and gross beta activity in suspended and dissolved solids and for total potassium-40 activity. After the third quarter of 1961, sampling at Phillips power Station and Dam No. 7 was discontinued, and by the end of the first quarter of 1962 sampling was also discontinued at the midland and East Liverpool stations (see figure 4); however the Pennsylvania State Health Department assumed responsibility for sampling and analytical programs at the latter two stations. Results for the last half of 1961 and the first half of 1962 are summarized in table 7.

Other Sampling Activities

Several programs of environmental sampling are of some interest to the Pennsylvania Department of Health. Two of these are currently active; a third, that of sampling vegetation and aquatic life, has been eliminated. River sediment and silt sample collections are made semiannually and sent as directed to the State Health Department for analysis. A series of ten soil samples are collected each year to be retained for later analysis if such data is required.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959	*July 1960*
First quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*October 1961*
First and second quarters 1960	*April 1962*

TABLE 7.—GROSS ALPHA AND BETA CONCENTRATIONS IN THE OHIO RIVER

[Average concentrations in $\mu\mu$c/liter]

Sampling station	Third quarter 1961		Fourth quarter 1961		Calendar year 1961		First half 1962	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Upstream:								
Phillips Power Station	1.0	12.4	[a]	[a]	[a]	[a]	[a]	[a]
Shippingport intake	1.3	17.7	4.9	31.8			3.9	38.8
Downstream:								
Shippingport outfall	1.2	27.7	1.2	25.9			2.0	42.1
Midland intake	1.8	15.8	3.2	34.8	[b]	[b]	[b]	[b]
Dam No. 7	1.4	12.5	[a]	[a]	[a]	[a]	[a]	[a]
East Liverpool, Ohio	1.1	11.5	1.4	24.3	[b]	[b]	[b]	[b]

[a] Station discontinued sampling after third quarter 1961.
[b] Monitored separately by the Pennsylvania Department of Health since the end of 1961.

Reported Nuclear Detonations

APRIL 1963

Only one nuclear detonation was announced by the Atomic Energy Commission during the month of April 1963. Abritrarily referenced by *Radiological Health Data* as test number 102, this test of low yield range was conducted underground at the Nevada Test Site on April 5. (Low yield range has been announced as being less than 20 kilotons yield.)

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UNITS AND EQUVALENTS

For the convenience of the *Radiological Health Data (RHD)* reader a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
Bev	billion electron volts	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	precipitation: $\text{mm} = \frac{\text{m}\mu\text{c/m}^2}{\mu\text{c/liter}} \times 1000 = \frac{\text{liter}}{\text{m}^2}$
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μc = 10^{-12} curies
r	roentgen	
μc	micromicrocurie	1 μc = 2.22 dpm

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